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[656]

Competition by roads, waterways and airways.

(Continuation) (1).

France, Argentina, British India, French Indo-China and Portugal (Mozambique Colony).

FRANCE.

The following note we owe to the courtesy of the Management Committee of the French Main Line Railways; it deals with the present state of affairs and the measures taken during the second quarter of 1934.

I. — Road competition.

A. — Statistics relating to competition. Passengers.

Length in km. *(in miles)* of the motor services regularly operated in France.

	Alsace-Lorraine.	*Est.*	*State.*	*Nord.*	*Paris-Orleans and Midi.*	*P. L. M.*
	1. *Permanent services.*					
a) By the railways	None.	None.	None.	None.	None.	None.
b) By concession-holders on behalf of the railways . .	150 (*93.2*)	533 (*331.2*)	193 (*119.9*)	488 (*303.2*)	300 (*186.4*)	1 233 (*766.1*)
c) By other public undertakings	7 300 (*4 536*)	12 128 (*7 530*)	30 050 (*18 672*)	16 705 (*10 380*)	59 800 (*37 159*)	28 000 (*17 400*)
	2. *Temporary services.*					
a) By the railways	None.	None.	None.	None.	None.	None.
b) By concession-holders on behalf of the railways .	1 476 (*917.1*)	23 (*14.3*)	None.	93 (*57.7*)	6 980 (*4 337*)	None.

(1) See *Bulletin of the International Railway Congress Association*, June 1934 to February 1935.

B. — Statistics relating to competition. Goods.

Number of lorries operating in France:

There are no more recent official figures than those given in the last note (Cf. *Bulletin*, September 1934).

C. — Measures taken by the French Railways to fight motor competition.

1. Technical measures.

a) *Organisation of motor services.*

In view of the decree of the 19th April 1934, on the co-ordination of road and rail transport, no new motor services have been organised by the Railways nor by firms working in agreement with them, since the above-mentioned decree was passed.

b) *Increase in the speed of trains.*

Further important accelerations have been made in the timings of the rapides and express trains, and the efforts of the Railways are directed to making the speed of such trains as high as the maximum allowed by the gradient section of each line concerned, and compatible with the services the trains have to work.

Many stopping trains likewise have been accelerated, especially on the State, and on the Paris-Orleans and Midi Railways; it has been found possible to make valuable savings on the journey times of these trains.

c) *Introduction of rail motor coaches.*

In following out their plans for extending the use of rail motor-coaches, the Railways have put new vehicles of this type into service both to replace trains insufficiently used on secondary lines and to start new services.

During the second quarter of 1934 the following new services among others were worked by rail motor-coaches :

Langres—Chaumont;
Cambrai—Douai;
Lille—Valenciennes;
Beauvais—Amiens;
Rennes—Quimper;
Rennes—St-Malo;
Paris—Deauville;
Rochefort — La Rochelle — Poitiers — Tours;
Alès—Lavelade; etc...

During July 1934 :

Paris—Vichy—Clermont;
Laroche—Avallon;
Paris—Tourcoing;
Paris-Bagnoles-de-l'Orne; etc...

Some of the Railways have also increased the number of workings covered by rail motor coaches already in service.

d) *Introduction of new accelerated services.*

Thanks to the introduction of rail motor coaches, it has been found possible to introduce accelerated services between places served by these vehicles, as well as over long-distance journeys by running the rail motor coaches in connection with rapides or express trains.

As an example, by using rail motor coaches over part of the route, two services in each direction link up Paris-Quai d'Orsay with La Rochelle and Rochefort via Poitiers and Niort. By a similar combination of Paris-Orleans express trains and State rail motor coaches, Royan and Saintes are directly linked up with Paris-Quai d'Orsay through Angoulême.

On the other hand, two fast services in each direction have been organised by the Nord Railway, in conjunction with

the Belgian National Railways Company, between Lille and Ostend, by rearranging the existing timetables.

e) *Containers.*

No new steps have been taken in this connection during the second quarter of 1934, but there has been an increase in the number of privately owned containers registered as well as in the number of railway containers put into service.

f) *Door to door services.*

In order to give railway users further advantages, the Paris-Orleans and Midi Railways have organised, between Orleans and Tours, a combined railway and motor lorry goods service (F. A. D. Service Fer-Auto-Domicile), the lorries operating inside a certain area along this section of line :

— Goods and parcels cartage collecting services based on a centre station;

— Goods and parcels cartage delivery services of goods arriving by rail at a centre station;

— Transport of goods from door to door within certain areas.

The State Railways, for their part, have similarly undertaken door to door collection and delivery of goods on the Etoile de Mortagne by means of the lorries which cover the goods traffic on the various lines of which this « star » is composed.

g) *Other measures.*

Development of parcels and lorry services : on the State Railways during the second quarter of 1934, 97 places served by services of this kind despatched most of their traffic by railway instead of by road.

2. Commercial measures.

a) *Rates.*

Special fast and slow goods rates, Nos. 1/101. — Reduced rates for livestock consigned for Strasbourg, Metz and Mulhouse (8th June 1934).

Special slow goods rate Nos. 10/110, Chapter 3, § 1. — Introduction of a fixed rate for limestone carried from Maizières-lez-Metz to Distroff (3rd May 1934).

Special slow goods rate No. 100 (grouped consignments), Chapters III, § IV. — Introduction of fixed rates with a contract clause for grouped consignments between Metz, on the one hand, and Colmar, Mulhouse and Strasbourg on the other (17th May 1934).

International slow goods rate No. 202. — Introduction of a fixed rate for carrying wheat flour and bran from Graffenstaden, Strasbourg-Neudorf and Strasbourg (Port du Rhin) to Ensdorf-Saar (24th May 1934).

Special slow goods rate Nos. 20/120, Chapter 3. — Introduction of a fixed rate for carrying cocoa nibs from Strasbourg (Port du Rhin) to Lauterbourg (29th June 1934).

Special slow goods rate No. 100 (grouped consignments), Chapter 20, § II. — Extension to the competitive Thann-Marseilles traffic of the special arrangements made in favour of grouped consignments sent from Colmar and Mulhouse to Marseilles (29th June 1934).

Introduction, in the case of slow goods rates Nos. 6-106, of contract clauses for unclassified alcohol from certain stations on the State Railways to Suresnes-Puteaux. — Came into force on the 6th April 1934.

Introduction, in the case of fast goods rate No. 31, of fixed rates for butter,

cream and cheese for the Paris Central Markets from Couville and Carentan stations. — Came into force on the 8th June 1934.

Introduction, in the case of slow goods rates Nos. 11-111, of a fixed rate for carrying finished or rough dressed ashlars from St-Agnan-les-Marais to La Rochelle-Ville. — Came into force on the 5th July 1934.

Introduction, in the case of slow goods rates Nos. 11-111, of a fixed rate for carrying finished or rough dressed ashlars from Péronville to Orleans. — Came into force on the 5th July 1934.

Introduction of a fixed rate for conveying casks of cider from Livarot to Caen, in slow goods rate No. 306. — Came into force on the 27th May 1934.

b) *Other measures.*

Reduction in the transit time in the General slow goods rates (200 km. = 124 miles per fraction of 24 hours). — Came into force on the 1st June 1934.

Reduction in the demurrage charges in the case of privately owned wagons. — Slow goods rates Nos. 29-129, Chapter 4, and fast goods rates Nos. 21-121. — Came into force on the 8th July 1934.

Extension of the « express parcels » rates on secondary railways. — Came into force on the 1st July 1934.

Modification of the general rates and various special rates in order to enable passengers to travel by a different route than that shown on their tickets, on either the outward or return journey, if need be, on payment of a supplement for any increase in mileage involved, even if the new route is partly over other systems than those over which it was booked. — Came into force on the 17th May 1934.

Modification of clause 29 of the general fast goods rates dealing with the charges for luggage in station cloakrooms. — Came into force on the 5th July 1934.

Modification of the special period of availability of return tickets issued on the occasion of certain legal holidays. — Came into force on the 22nd June 1934.

D. — Modifications in legislation likely to affect the relations between the railways and the motor hauliers.

Decree of the 30th June 1934, limiting the dimensions and weight of vehicles running on the public highways.

In order to reduce the financial cost to the State, the decree of the 30th June 1934 lays down limits for the transverse width, total length, and weight per axle of vehicles.

Width : The maximum width of vehicles and their load is limited to 2.35 m. (8 ft. 2 7/16 in.).

Length : The maximum length is fixed at 10 m. (32 ft. 8 in.) in the case of a single vehicle and 12 m. (39 ft. 4 1/2 in.) in the case of a vehicle hauling a trailer.

Weight : The maximum total weight is limited to 15 tons.

Finally, in the case of crossings and passing (overtaking) places on roads less than 5 m. (16 ft. 5 in.) wide, vehicles exceeding 2 m. (6 ft. 6 3/4 in.) in width or 8 m. (26 ft. 3 in.) in length overall, including trailer, must slow down, and if need be stop and clear the road, so as to allow smaller vehicles to pass.

Temporary measures. — The measures dealing with the length, width and weight of vehicles will only apply, however, to :

a) new vehicles put into service after the first January 1936;

b) all vehicles of no matter what age, after the 1st January 1939.

The clauses of the decree of the 30th June appear to prevent excessive expenditure in improving the national road system; in addition, they will oblige the motor vehicle industry to return to a line of development which logically it should never have left. The modification in the builders' designs will be considerable, as vehicles exceeding 15 tons in total weight (tare plus load) and 2.50 m. (8 ft. 2 7/16 in.) in width are currently used today.

Limitation of vehicle capacity resulting from the clauses of this decree, by increasing the cost price of road transport for equal capacity, will also have a considerable effect in reducing road competition; but it would be difficult to estimate the actual extent thereof at the present time.

II. — Competition from water transport.

A. — Statistics relating to such competition.

General table showing traffic for the second quarter of 1934 and comparing it with the tonnage for the previous year.

Tonnage loaded during the 2nd quarter.		Difference in comparison with 1933.	Tonnage loaded since the beginning of the year.		Difference in comparison with 1933.
1934	1933	Decrease, %	1934	1933	Decrease, %
13 433 197	13 817 806	2.8	25 009 339	25 427 213	1.6

B. — Steps taken by the railways to meet water competition.

Introduction, in the case of slow goods rate No. 11-111, of a reduced scale for carrying macadam, gravel, and sand from Mur-de-Bretagne to stations on the Loudéac to Fret and Loudéac to Camaret-sur-Mer lines. — Came into force on the 6th April 1934.

Introduction, in the case of slow goods rates No. 11-111 of a fixed rate for the transport of dressed ashlars from Vailly to Lisieux. — Came into force on the 17th June 1934.

C. — Modifications in legislation likely to affect the relations between the railways and the waterways.

1. *Law of the 30th June 1934 regulating inland water transport.*

This decree lays down (clauses 1 to 6) that all inland water transport contracts must be made in writing and must conform with the standard form prescribed by the Administration. Any contracts which do not so conform with the standard clauses shall be null and void.

These agreements, under penalties laid down in clause 9, have to be drawn up in the public Exchanges (clause 8) which will be set up at the shipping offices (such offices are already in existence in the North of France and are to be opened in other districts) and according to clause 7, all contracts have to be approved at one of these offices.

The shipping offices can be set up, either by a chamber of commerce, or by a group of users of navigable waterways (article 11) in each main loading center.

These offices, besides approving the transport agreements and publishing the freight rates granted, will have to take steps to facilitate traffic relations and to act as an intermediary between the different users of the waterways.

The offices will also have to organise a public freight market in the Exchanges set up for this purpose. They will also set up a corporation of shipping agents (clause 13) whose members alone will be able to represent third parties on the freight Exchanges.

Regulations laid down by the public administration will define the way in which the different measures indicated above are to be applied (clause 14).

Clause 15 states finally that the decree does not apply to traffic on the Rhine nor to water transport originating outside France.

2. *Decree of the 31st March 1934*, modifying various articles of the decree of the 6th February 1932, *regulating the organisation of navigable inland waterways*, and in particular clauses 13 and 14.

The clauses, in their revised form, deal with regular navigation services in contradistinction to the ordinary navigation of all boats not working a regular service open to the public.

Operation of a regular service is subject to specified conditions and has to be licensed by the State Council.

All requests for licences must be addressed to the Minister of Public Works with an explanatory note and the proposed specification giving, in particular, the maximum and minimum rates, and the maximum load any one consignor can forward to any one destination in one boat.

The licence is granted for a maximum period of five years, but can be renewed.

III. — Air competition.

A. — Traffic statistics of the main French air lines.

1. Passengers carried during the second quarter of 1934 :
14 229.

2. Parcels, papers, excess luggage carried during the second quarter of 1934 :
374 324 kgr. (824 000 lb.).

3. Mails :
56 076 kgr. (123 400 lb.).

B. — Steps taken by the railways to meet this competition.

The rapide No. 122 (Amsterdam-Brussels-Paris) is run 15 minutes earlier to enable passengers going from Holland to the south of France to catch train No. 15 at the Paris P. L. M. station for Marseilles, Nice and Mentone.

C. — Modifications in legislation likely to effect the relations between railway and air transport.

None.

* * *

The Management Committee of the French Main Line Railways has also sent us the following note, which we will publish here, although it will also be dealt with in further notes on the 3rd and 4th quarters of 1934.

In the case of passenger traffic, the Main Line Railways, in accordance with the terms of the decree of the 19th April 1934, have already made nine agreements with road transport firms and secondary railways, for co-ordinating the working in the Doubs, Moselle, Marne, Hautes and Basses Pyrénées « departements », the Valenciennes, Dunkirk and Amiens areas, and the Seine-Inférieure and Deux-Sèvres « departements » and neighbouring districts.

There is, of course some variation in these agreements, as they affect such very different regions.

At the present time, they are being examined by the Road and Rail transport Coordination Committee, which has been meeting at the Ministry of Public Works since August 1934. This Commission has to decide, from the different agreements made, what are the general principles to be applied throughout the country to ensure co-ordination of passenger transport services. It seems likely that the Committee will very shortly come to final conclusions in this connection.

In the case of goods traffic, the only agreement that so far has been made concerns the Seine Inférieure « departement » and the neighbouring district. The question will be studied by the Co-ordination Committee as soon as their investigations into passenger traffic can be considered as completed.

Negociations have also been begun between the railways and representatives of inland navigation undertakings; two agreements have already been made, one in the case of navigation on the Rhine, and one dealing with canals in the south of France. Moreover, a decree of the 21st September 1934 has laid down the conditions of application of the law of the 16th May 1934 on the co-ordination of railways and inland navigation; the regional commissions and the Central Committee for co-ordinating railways and navigable watermays have been formed, and the latter body has just held its first meeting.

* * *

ARGENTINA

Buenos-Ayres and Pacific Railway.

The creation of a Transport Corporation, monopolising all form of passenger traffic in the City of Buenos Aires, was approved last month by the Constitutional Affairs and Municipal Legislation Committees of the Chamber of Deputies.

The Transport Corporation will combine under the same financial, administrative and technical management, all means of collective transport of passengers in the City of Buenos Aires and existing extensions, as also auxiliary services outside the city borders, including tramways, omnibuses and collective taxis, but excluding the State-owned railways, the transport of tourists and other means of transportation not of a public character.

The bill for co-ordination of transports is scheduled to be dealt with in the extraordinary sessions of Congress which are now being held, and it is hoped that the bill will be passed.

* * *

BRITISH INDIA

Bengal Nagpur Railway.

There have been no changes in the basic measures already reported.

Reduced 3rd-class passenger fares have been introduced on some more sections and also a few other port-to-port goods rates.

* * *

FRENCH INDO-CHINA.

During the 3rd quarter of 1934, the *Compagnie française des Chemins de fer de l'Indochine et du Yunnan* introduced, for a period of three months, reduced rates for 1st, 2nd and 3rd-class passengers between Hanoi and Hai-Fong. In addition, various modifications were considered — in force on the 1st No-

vember 1934 — such as : reduction in the kilometric passenger rates in all classes; creation of fixed rates for certain classes over certain routes; increase in the amount of luggage allowed free for 4th-class passengers.

In the case of goods traffic, the Company has applied a common rate with the *Chemins de fer de l'Indochine*, which includes fixed rates for transport of certain goods. It is also considering the steps to be taken as regards rates to recover from motor transport the traffic in early fruit and vegetables, foodstuffs, woven fabrics, etc.

Application of the decree of the 4th July 1934, regulating the working of motor passenger and goods transport services, has been deferred to the 14th January 1935.

* * *

PORTUGUESE EAST AFRICA

Mozambique.

The Harbours and Railways Administration for the Colony has been authorised, by the Government, to set up two new road services intended to act as feeder lines, one to the Inhambane line which serves the bay of that name, and the other to the Mozambique line, respectively 27 and 62 km. (16.8 and 38.5 miles) long.

It has also obtained control of the privately owned lorry traffic on the roads and the ferry services across the large rivers where there are no bridges. In this connection a decree recently issued allows the railway to exact a toll on private lorries using the ferries; railway lorries carrying feeder traffic for the railway are exempt from this tax.

[656. 222.1]

Note on Train Speeds,

by Lionel WIENER,
Professor at the University of Brussels.

PART II *(Continued).* [1]

Train speeds and services in different countries.

V. — HOLLAND.

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CHAPTER XXVI.

The railway system.

XXVI-1. — General. — Whilst the great Belgian arteries are essentially transit lines, this characteristic only applies to the Dutch railways in the case of the East to West lines covering Anglo-German traffic. On the other hand, the South to North lines are lines « to destination ».

Moreover, instead of the capital being at the centre of the system, there are, in Holland, three « conjugated » towns, Amsterdam, The Hague, and Rotterdam, all of which are situated in the West along a North to South line. Each important route must serve these towns, either passing through them all, or splitting up into three branches at Utrecht.

King William, the promoter of many successful works, was the first to grasp

(1) Cf. *Bulletin of the International Railway Congress Association*, October and November 1933, pp. 885 and 1027; January, May, June and July 1934, pp. 63, 407, 561 and 653; February 1935, p. 141.

the necessity of tackling railways in this way when, at his own risk, he built the *Dutch Rhenan Railway* (1), with its branches from Utrecht (via Gouda) to The Hague and Rotterdam.

XXVI-2. — **Hypsography of the country.** — Generally speaking, the West, Centre, and North of Holland consist of alluvial plains, which have made it possible to build the railways very nearly level throughout, the gradients rarely exceeding 1 in 500 except on quite short sections where they rise to 1 in 200. Most Friesland lines are seldom more than 13 feet above sea level; the Stavoren and Leeuwarden railway is less than 10 feet above sea level, and the Hoorn and Medemblik, 2 1/4 feet.

Many of the lines are even below sea level : from Rotterdam to the Hague, the railway drops to 11 1/2 feet, and the Alkmaar line to 3 ft. 10 in. below datum. The greater part of the system between Amsterdam and Haarlem, Leiden and Nieuwersluis, which crosses the old Haarlemermeer (2) drained by William I (fig. 147), is also below sea level.

The country becomes hilly along the German frontier, and the railway crosses the watersheds at a height of some 54 m. (164 feet) (3) by gradients of as much as 1 in 115. Finally at the southern end of Limburg, the maximum altitude of 426 feet is reached at Heerlen (4).

XXVI-3. — **The former companies** (fig. 148). — The economic principles formerly in vogue had a great effect on the present situation of the Dutch railway system. With two exceptions (5) the companies then operating were bought up and the whole grouped system (6) leased to two operating companies : the *S.S.* and the *H. IJ. S.M.* (7). The lines were divided up between them in such a way that the two companies compete against each other, not only in the case of the international services, but also for most of the important internal communications. However, in order to avoid building useless lines, nearly 400 km. (250

(1) *Nederlandsche Rhein S. M.*

(2) This inland lake had an area of 181 km² (70 sq. miles). In connection with the work now in hand on the Zuiderzee, it seems interesting to recall to mind similar work carried out between 1840 and 1852. However, the first railway lines were only built in 1902, and by 1918 there were 116 km. (72 miles) of lines.

The Haarlem-Amsterdam line drops to 12 ft. 2 in. below datum; over half of it is below sea level, and this proportion is still greater in the case of the Amsterdam-Nieuwersluis (1915) line, which drops to 5.30 m. (17 ft. 5 in.) below datum. Almost the whole of the Nieuwersluis-Leiden line is below sea level.

(3) The Amersfoort-Apeldoorn line, which rarely is above 65 1/2 feet altitude, reaches 154 feet. Weert is 128 feet above datum.

(4) The Nijmegen-Kleef line reaches 164 feet altitude near Oldenzaal, by 1 in 115 gradients.

The line from Sittard (+ 164 feet) to the frontier (+ 525 feet), in the Aix la Chapelle direction, climbs to 243 feet at Lutterade, by means of a 1 in 100 gradient half a mile long.

(5) The *N. B. D.* (*Noord Brabant Duitsch Sp. M.*) and the *N. C.* (*Nederland Central Sp. M.*).

(6) Thus the *S. S.* handed over to the *H. IJ. S.* the Dordrecht-Elst, the Leeuwarden- Stavoren. the Amelo-Hengelo, etc., lines. On the other hand, the 228 km. (141.7 miles) bought from the *Ned. Rheinsche S. M.* were given to the *S. S.*

(7) The *S. S.* was the Company operating the State Railways (Maatschappy tot exploitatie van Staats-Spoorwegen).

The *H. IJ. M.*, Dutch Railway Company, (*Hollandsche IJzeren Spoorweg Maatschappij*).

Fig. 147. — Gradient section of the Amsterdam-Alsmeer and Haarlem line.

The position of fixed bridges is shown by heavy lines; that of swing bridges by circles.
The first column of figures refers to the altitudes; the second to gradients or distances corresponding to a rise of one metre (3.28 ft.); the third column gives the length of the gradients.

TABLE 149.

SECTIONS OF THE DUTCH RAILWAY SYSTEM COMMON TO TWO COMPANIES.

LINE.	S. S.	H. IJ. S.	N. C. S.
Utrecht-Rotterdam	53	runn. rights.	...
Rotterdam-Esschen	66	runn. rights.	...
Utrecht-Amersfoort	...	runn. rights.	22
Dik-Kampen	...	7	runn. rights.
Arnhem-Venlo	80	runn. rights.	...
Do. -Emmerich	14	runn. rights.	...
Nijmegen-Groesbeek	runn. rights	9	...
Zevenaar-Winterswijk	runn. rights.	50	...
Almelo-Oldenzaal-Salzbergen	runn. rights.	56	...
Hengelo-Enschede	9	runn. rights.	...

miles) of line were partly joint lines, i.e. they belonged to one or other of them and the other had running rights over them. Table 149 gives a list of such lines; their length is shown in the column corresponding to the owning company.

TABLE 150.

COMPETING LINES (fig. 148).

ROUTE FOLLOWED.	H. IJ. S. via	S. S. via
International traffic.		
To England	Hook of Holland.	Flushing.
Amsterdam to Berlin	Apeldoorn-Hengelo.	Utrecht-Hengelo.
Hook of Holland or Flushing to Berlin.	Kesteren-Hengelo.	s'Hertogenbosch.
Amsterdam to Cologne	Kesteren-Kleef.	Utrecht-Emmerich.
Do. to Brussels, etc.	The Hague	Utrecht.
Home traffic.		
Rotterdam-Arnhem	Kesteren.	Utrecht.
Amsterdam-The Hague	Leiden.	Gouda.
Do. -Rotterdam	Do.	Do.
Do. -Roosendaal	Do.	Do.
Do. -Utrecht	Hilversum.	Nieuwersluis.
Do. -Venlo	Kesteren.	Boxtel.
Do. -Hengelo	Apeldoorn.	Arnhem.
Do. -Leeuwarden	Enkhuizen.	Zwolle.

THE SERVICES FROM AMSTERDAM TO ROTTERDAM VIA UTRECHT AND VIA THE HAGUE. — The most intense competition was that between Amsterdam and Rotterdam. The *H.S.* line, via The Hague, includes the oldest railway built in the country. This was the 19 km. (11.8 miles) of 1.94-m. (6 ft. 4 3/4 in.) gauge line from Amsterdam to Haarlem, which distance was then covered in 30 minutes. This section was opened on the 24th September, 1839. Doubtless from motives of prudence, though the timetables gave the hour at which the trains started, no mention was made of the time of arrival.

This line, which has always been the best earning line of the system, suffered at first from the expropriation act being badly drafted : the case of the farmer van der Gaag, who demanded 20 000 florins for the right of way through a field and footpath, a distance of 530 m. (1 738 feet), instead of the mere 100 offered by the railway, is a classical example (1).

(1) The lawsuit was not finished in time for the inauguration of the railway, so that the latter was run round the farm by meaus of a horseshoe bend, having so small a radius that a special locomotive was needed to run the trains around it. Public opinion compelled the farmer to give way unconditionally four days after the railway was opened.

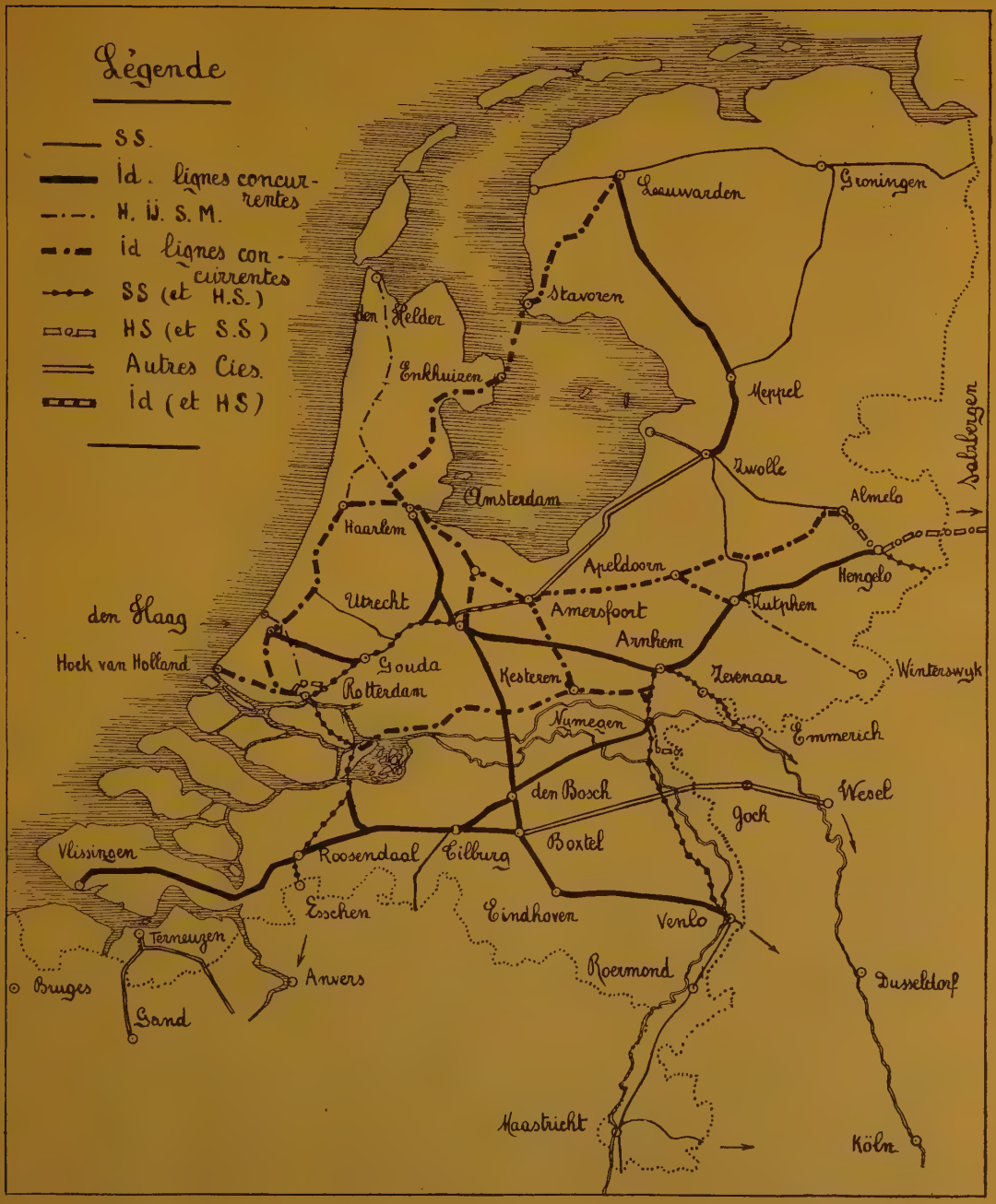

Fig. 148. — Division of the Dutch railway system between the former companies.
The numerous competing lines are shown by heavy lines.
Note: Lignes concurrentes = competing lines. — Autres Cies = other companies.

Except the *Nederlandsche Rhein S.M.*, whose main line also started from Amsterdam, no other railway in the country was built to the wide gauge (fig. 149) which disappeared after some 25 years (1).

Rapid improvements took place on both the Amsterdam and Rotterdam lines. Up to 1912, the run was made, over the two routes, in 77 minutes, with a single stop at The Hague (on the *H.S.*), or at Gouda (on the *S.S.*), while three other trains each way stopped at Leiden and at Delft on the one hand, and at Nieuwersluis (2) and Woerden on the other.

The *S.S.* then started 55-minute non stop trains, whilst the *H.S.* journey still took 70 minutes owing to its including stopping at The Hague.

Since the war, the two systems have been amalgamated, and the *H.S.* line has been electrified, with complementary express steam services. The former *S.S.* line which avoids Utrecht by the 6-km. (3.7 miles) by-pass section between Breukelen and Harmelen, thereby reducing the total distance from 94 to 76 km. (58.4 to 47.2 miles), is no longer used, except by a couple of semi-fast trains each way (3).

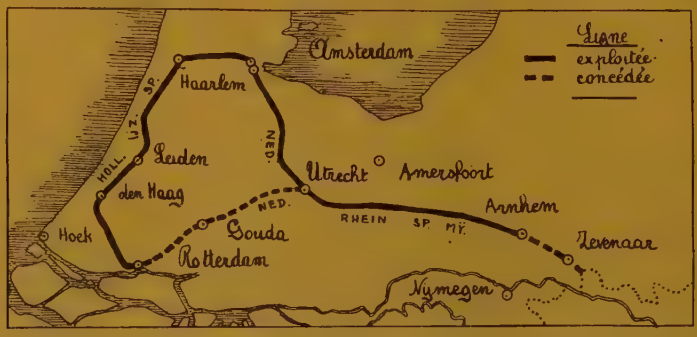

Fig. 149. — Former Dutch broad-gauge [1.94-m. (6 ft. 4 3/8 in.)] railway system.

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(1) The broad-gauge 1.94-m. (6 ft. 4 3/4 in.) Dutch track suffered in the same way as the English *Great Western*. Its drawbacks became apparent when it became necessary to link up Arnhem with the German standard-gauge line. Like on the *Great Western*, it was finally decided to reduce the width of the broad-gauge lines. Those belonging to the *N. R. S.* were converted to standard gauge in 1855, and those of the *H. S.* — which for a long time were unconnected with any standard-gauge lines — in 1864/66 only.

The original Brunel track with 20 kgr./m. (40.3 lb. per yard) rails on longitudinal sleepers was taken up after a few years and Vignole track with 37 kgr./m. (74.6 lb. per yard) rails, substituted for it.

(2) The famous contract made by the English *Great Western Company* with a Swindon caterer, according to which all the Company's trains had to stop there, is well known. A similar case existed in Holland, where in accordance with a clause in a land purchase contract, all trains had to stop at Nieuwersluis. When in 1873, this agreement was ignored, the owner had to be paid 10 florins compensation every time the contract was broken.

Again, just outside Amsterdam, certain land owners had been given the right, in 1720, to have for all time an uninterrupted view of the countryside. This led to lawsuits every time the Company put up any hindrance, the latter even including such items as signal posts or even telegraph wires.

(3) They take 1 h. 14 m. with two intermediate stops.

TABLE 151.

AMSTERDAM TO FRIESLAND OVERLAND OR COMBINED LAND AND WATER ROUTE.

RUN.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. Miles/h.	Number of stops.
OVERLAND.							
Amsterdam-Amersfoort-Zwolle-Leeuwarden	206	128.0	R8.30 a. m.	3.21	61.5	38 2	
Zwolle-Meppel	28	17.4	R9.44 a. m.	0.22	76.4	47.5	
Heerenveen-Leeuwarden	29	18.0	R1.30 p. m.	0.23	75.5	46.9	
LAND AND WATER.							
Amsterdam - Hokhuizen - Stavoren - Leeuwarden	135	83.9	5 30 p. m.	3.07	43.3	26.9	6 stops.
Hoorn-Enkhuizen	18	11.2	6.14 p. m.	0.15	72.0	44.7	
Enkhuizen-Stavoren	24	14.9	6 34 p. m.	1.08	24.1	15.0	
Stavoren-Workum	13	8.1	7.49 p. m.	0.12	65.0	40 4	
Sneek-Leeuwarden	22	13.7	8.18 p. m.	0.19	69.5	43.2	
OVERLAND.							
Amsterdam-Amersfoort-Zwolle-Groningen	217	134.8	1.32 p. m.	3.08	69.2	43.0	
LAND AND WATER.							
Amsterdam-Stavoren-Leeuwarden-Groningen	189	117 4	5 30 p. m.	4.16	44.3	27.5	
Leeuwarden-Veenwouden	14	8.7	R1.11 p. m.	0.12	70.0	43.5	
Buitenpost-Groningen	30	18.6	R1.35 p. m.	0.25	72.0	44.7	
Leeuwarden-Groningen	54	33.6	Do.	0.48	67.5	41.9	2 stops.

The track of the former *H. IJ. S.M.* included the crossing of the Zuiderzee between Enkhuizen and Stavoren. The distance shown on the timetable (30 km. = 18.6 miles) was increased by 6 km. (3.7 miles) for tariff purposes, to meet the extra cost of this service. Although the timetable says « tariff kilometres », this is the only instance of an extra charge in Holland, apart from counting fractions as complete kilometres.

The *S.S.* formerly used their own line from Amsterdam to Utrecht, then the *Noord Braband*'s for 89 km. (55.3 miles), and beyond that the *S.S.*'s again. After the amalgamation, the express trains were run directly from Amsterdam to Amersfoort through Hilversum and the former *H. IJ. S.* line (45 km. = 28.0 miles), which shortened the journey by 18 km. (11.2 miles).

Since the AMALGAMATION, internal competition has disappeared, but express trains have been retained on all the lines on which they ran previously. This explains the high percentage of express lines in comparison with the total mileage of the system, and the maintaining of services by alternative routes.

XXVI-4. — **The present-day companies.** — At the time the companies were amalgamated (1922), there were two large companies (fig. 148) : The *S.S.* (2 050 km. = 1 274 miles) and the *H.S.* (1 291 km. = 802 miles). Two other companies, the *Nederlandsche-Centraal S. M.* (1) and the *Noord Braband Duitsche S.M.* (2), each of which operated an important section of main line, had been bought out in 1918.

FOREIGN RAILWAYS IN HOLLAND. — These, now fewer than formerly, comprise : two Belgian lines (36 km. = 22.4 miles), and 28 km. (17.4 miles) of German ones.

The *Malines-Terneuzen Railway* operates 17 km. (10.6 miles) besides the 7-km. (4.35 miles) Selzaete-Sluiskil section of the former *Gand-Terneuzen* Railway, which had running powers over the 4 km. (2.5 miles) which led it to Terneuzen (3).

Two other Belgian Companies which built lines in Holland were bought out in 1899 and 1898 respectively :

The *Liégeois-Limbourgeois* Railway, and in particular the much more important *Grand Central Belge Company* (4).

Various German companies, who owned railway lines in Holland, were also bought out (5) and their lines handed over to the two national companies. In some instances, they retained a few sections which prolonged their lines into Holland (6).

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(1) The *N. C. S. M.* operated 89 km. (55.3 miles) of the Amsterdam-Friesland line, between Utrecht and Zwolle, besides a few branch lines, which brought up the total to 148 km. (92 miles).

(2) The only line operated by the *N. B. D. S. M.* was part of the main line from Flushing to Cologne. It ran from Boxtel to Gennep (49 km. = 30.4 miles) and thence to Goch (62 km. = 38.5 miles) towards Wesel on the right bank of the Rhine.

(3) The Belgian section of the *Gand-Terneuzen* line having been bought up by the Belgian State, the *Malines-Terneuzen* Railway operates its Dutch section.

(4) Actually it owned the following lines in Holland :

Belgian frontier — Roermond — German frontier towards Gladbach	49 km.	(30.4 miles).
Tilburg towards Turnhout	22 km.	(13.7 miles).
Roosendaal-Etten-Breda	24 km.	(14.9 miles).
Maastricht to the frontier towards Aix la Chapelle	28 km.	(17.4 miles).
Belgian frontier — Roosendaal — Zevenbergen — Moerdijk	31 km.	(19.3 miles).

The famous Moerdijk bridge (1 465 m. = 0.9 mile) long, which is situated on this section and was built by the Dutch Railways, is the only single-track section of the entire Belgian frontier to Amsterdam line.

(5) In particular :

Nijmegen, Frontier, towards Kleef	14 km.	(8.7 miles)	(*From the Rhine, left bank*).
Almelo-Hengelo	16 km.	(9.9 miles)	(Taken over by the *H. S.* from the *S. S.*).
Hengelo-Frontier	18 km.	(11.2 miles)	(*Almelo-Salzbergen* Company).
Zutphen-Winterswijk	43 km.	(26.7 miles)	(*Ned. Westfalisch Sp. M.*).
Enschede, Frontier, towards Ahaus	7 km.	(4.35 miles)	(*Ahaus Enschedeer Eis. Ges*).

(6) Foreign frontier sections of line forming extensions to the national lines into Holland :

S. S. : Nieuwe Schans towards Zent	1 km.	(0.6 mile)	in Holland.
H. IJ. S. : Winterswijk towards Borken	7 km.	(4.35 miles)	
Do. towards Bocholt	7 km.	(4.35 miles)	
S. S. : Venlo towards Viersen	3 km.	(1.86 miles)	
Do. Kempen	3 km.	(1.86 miles)	
Do. Kaldenkirchen	5 km.	(3.1 miles)	

In addition, the *Bentheimer Kleinbahn* operates in Holland 2.5 km. (1.55 miles) of secondary line from Coevorden towards Neuenhaus.

Although operation of most of the other international lines ceases at the actual frontier (1), a few Dutch lines still run into Germany :

H. S.: Oldenzaal, Frontier (7 km. = 4.35 miles), Bentheim (15 km. = 9.3 miles), Salzbergen (29 km. = 18 miles).

S. S.: Zevenaar, Bebberich frontier (4 km. = 2.5 miles), Etten (8 km. = 5 miles); Emmerich (17 km. = 10.6 miles).

Former *N. B. D.:* Boxtel, Gennep (49 km. = 30.4 miles), Frontier (53 km. = 32.9 miles), Goch (62 km. = 38.5 miles), Wesel (101 km. = 62.8 miles).

S. S.: Heerlen, Kerkrade, Frontier (4 km. = 2.5 miles), Herzogenrath (7 km. = 4.35 miles).

CHAPTER XXVII.

The trains.

XXVII-1. — **Official time.** — Holland is the only European country which has not adopted the standard zone system, but has kept to Amsterdam time which is 19 minutes 40 seconds in advance of the corresponding zone time.

In this connection, it is interesting to remember that formerly every town had its own time. The first attempt at standardisation was due to the English Railways which, in 1841, all adopted Greenwich mean time (2) and the British Parliament did likewise... after 39 years. Other countries also used the time of their capital city (3) : in France, the railways adopted the legal time (Paris meridian) with a difference of 5 minutes. Madrid time was 20 minutes later and Athens time, up to the war, was 40 minutes later than Central Europe time.

It was Sir Stanford Fleming, Engineer of the *Canadian Pacific Railway* who, on observing that the 5 hours difference in time between the east and west of Canada corresponded to 4 minutes per degree of longitude, suggested that the world be divided up into 24 time zones. This excellent plan, which considerably simplified the reading of international timetables was, only ratified by the Canadian Parliament on the 18th November, 1883.

Italy's adoption of the 24-hours notation, which is used everywhere except in Great Britain, happily completed this improvement.

XXVII-2. — **Through coaches in international services.** — The Dutch services actually meet two very distinct needs : the Anglo-German transit services, and services to Holland only.

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(1) Such as the following lines of the *S. S.* :
Hengelo-Enschede (8 km. = 5 miles), Frontier (14 km. = 8.7 miles), Gronau (17 km. = 10.6 miles).
Eindhoven, Belgian frontier (18 km. = 11.2 miles), Achel (19 km. = 11.8 miles).
Roosendaal, Belgian frontier (8.147 km. = 5.05 miles), Esschen (8.89 km. = 5.52 miles).

(2) On the *Great Western Ry.* alone, there was a difference of 15 minutes between places at the different ends of the system. The local time in Reading was 4 minutes later than Greenwich mean time, Chippenham was 8 minutes later, Bath 11, and Bridgewater 14. This information has been taken from the *Railway Gazette.*

(3) Before the Eastern States adopted zone time, the following local times were taken as the basis (in 1914) corresponding to mid-day in Central Europe :

St Petersburg	1 p. m.	Vladivostok	7.47 p. m.
Irkutsk	5.57 p. m.	Peking	6.37 p. m.
Kharbine	7.26 p. m.	Tokio	8 p. m.

The time at Amsterdam was then 11.20 a. m., and at Athens 12.25 p. m.

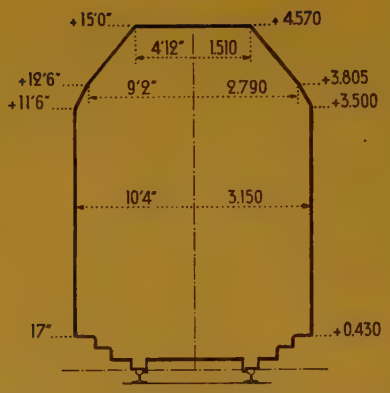


Fig. 150. — Loading gauge of Dutch standard track-gauge lines.

On the contrary, the Belgian international services are mostly transit services, whereas Switzerland, where services to holiday centres predominate, has also a number of transit services.

Figure 150 shows the Dutch loading gauge.

XXVII-3. — **Weight of the trains.** — Even in the case of passenger trains, the weight is often very considerable. The following are a few examples (October 1933) excluding the locomotive's weight of 141 or 134 tons :

P 56	Amsterdam C. S.-Esschen	320	tons	(315.0	Engl.	tons).
87	Do. -Eindhoven . . .	470	—	(462.5	—	).
D 111	Amersfoort-Bentheim	470	—	(462 5	—	).
126	Groningen-Amersfoort	600	—	(590.5	—	).
137	Flushing-Roosendaal	600	—	(590.5	—	).
D 137	Roosendaal-Bentheim	460	—	(452.7	—	).
D 174	Apeldoorn-Amsterdam	670	—	(659 4	—	).
D 271	Utrecht-Emmerich	550	—	(541.3	—	).
D 272	Arnhem-Utrecht	700	—	(689.0	—	).
D 281	Emmerich- Do.	650	—	(639 7	—	).

Figure 151 shows, in diagram form, how some of these trains are made up.

XXVII-4. — **The express trains.** — As can be seen from the cartogram (fig. 152) Holland has a greater proportion of express train lines than most other countries. They belong to four groups :

international trains;
boat trains;
ordinary express trains;
intensive interurban express train services.

Various methods of traction also are used : steam locomotives, electric traction (Chapter XXVIII-2), petrol or diesel-electric rail motor coaches or trains (Chapter XXVIII-3). Even on the electrified lines, steam locomotives are still used to haul heavy passenger trains, international or main line trains, as well as goods trains.

XXVII-5. — **Boat trains** (fig. 153). — Flushing and Rotterdam were the ports of the *S.S.*, and the Hook of Holland that of the *H.S.* When these two companies were amalgamated, the number of maritime services was reduced, so that to-day there is only one night service between England and Holland, which runs between Harwich and The Hook, and one day service from Folkestone to Flushing (1).

(1) Distances :

	Nautical miles.	Km.		Nautical miles.	Km.
Harwich-Hook of Holland .	103	194	Harwich-Antwerp	134	252
Folkestone-Flushing . . .	100	188	Harwich-Rotterdam . . .	121	227
Queenborough-Flushing . .	110	206			

TABLE 152.

BOAT TRAINS. (Fig. 153.)

(Non-stop runs are shown **in heavy type**).

Port.	DESTINATION.	Distance. Km.	Distance. Miles.	Time of departure	Time spent.	Speed. Km./h.	Speed. Miles/h.	—
ook of Holland.	Schiedam-Amsterdam	105	65 3	6.26 a. m.	1.45	60.0	37.3	
Do.	Rotterdam	28	17.4	6.26 a. m.	0.32	52.5	32.6	1 stop.
Do.	Utrecht-Zevenaar (Cologne) . . .	152	94.5	6.59 a. m.	2.52	53.0	32.9	Rheingold + Amsterdam.
Do.	Utrecht-Arnhem-Hengelo (Berlin) .	223	138.6	7.25 a. m.	3.36	61.9	38.5	D 111.
Flushing.	Roosendaal-Amsterdam	219	136.1	6.33 p. m.	3.34	61.4	38.2	6 stops; 137.
Do.	Do. Hengelo (Berlin)	282	175.2	6.33 p. m.	4.11	67.4	41.9	D 137.
	Flushing-Roosendaal . . .	75	46.6	**12.43** p. m.	**0.54**	**83.3**	**51.8**	
	Roosendaal-Breda	25	15.5	**7.34** p. m	**0.20**	**75.0**	**46.6**	
	s'Hertogenbosch-Nijmegen .	43	26.7	**8.35** p. m.	**0.35**	**73.7**	**45.8**	
	Nijmegen-Arnhem	19	11.8	**R12.24** p. m.	**0.16**	**71.2**	**44.2**	
	Arnhem-Zutphen	30	18.6	**9.36** p. m.	**0.25**	**72.0**	**44.7**	D 137.
	Zutphen-Hengelo	46	28.6	**R 8.15** a. m.	**0.34**	**81.2**	**50.5**	D 138.
Do.	Roosendaal-Venlo (Cologne) . . .	205	127.4	6.16 p. m.	2.55	70.3	43.7	2 stops; D 78.
	Flushing-Eindhoven	153	95.1	**6.16** p. m.	**2.00**	**76.5**	**47 5**	
	Eindhoven-Venlo	52	32 3	**R10.43** a. m.	**0.39**	**80.0**	**49.7**	
Enkhuizen.	Hoorn-Amsterdam	61	37.9	9.57 a. m.	1.07	54.6	33.9	6 daily, 3 stops.
Do.	Alkmaar (Haarlem)	41	25.5	10.04 a. m.	0.44	55.9	34.7	6 daily.
Stavoren.	Leeuwarden-Groningen	104	64.6	3.39 p. m.	1.49	57.2	35.5	7 stops.
Do.	Enkhuizen (sea passage)	24	14.9	6.34 p. m	1.08	24.1	15.0	5' and 7' stops.
Marseilles.	Paris-Brussels-The Hague	1353	830.8	9.28 p. m.	21.40	62.4	38.8	Every 3 weeks.

Special trains link up all these ports with the three towns (Rotterdam, The Hague and Amsterdam), as well as with Cologne, and beyond (Berlin).

In addition there is, connecting up with the steamers of the *Rotterdam Lloyd*, a special long-distance boat train from The Hague to Marseilles. On the return run it follows, according to the time of arrival at Marseilles, one of six given timetables, in the same way as the special *P. and O.* trains did before the war, from Brindisi and Calais, and as the special Marseilles and Calais trains still do.

These trains are timed at higher speeds than the heavy trains running over the same metals.

XXVII-6. — **Suburban trains.** — STANDARDISED SERVICES. — Lines used by 6 000 to 30 000 passengers a day are operated by trains running at hourly or even half-hourly intervals :

Amsterdam	to Rotterdam and Dordrecht.
Do.	to Alkmaar.
Haarlem	to Uitgeest.
Rotterdam	to Maassluis and Hook of Holland.
Amsterdam W. Park . .	to Amstelveen.

XXVII-7. — **Goods trains.** — Fast trains are booked to run at 75 km. (46.6 miles) an hour.

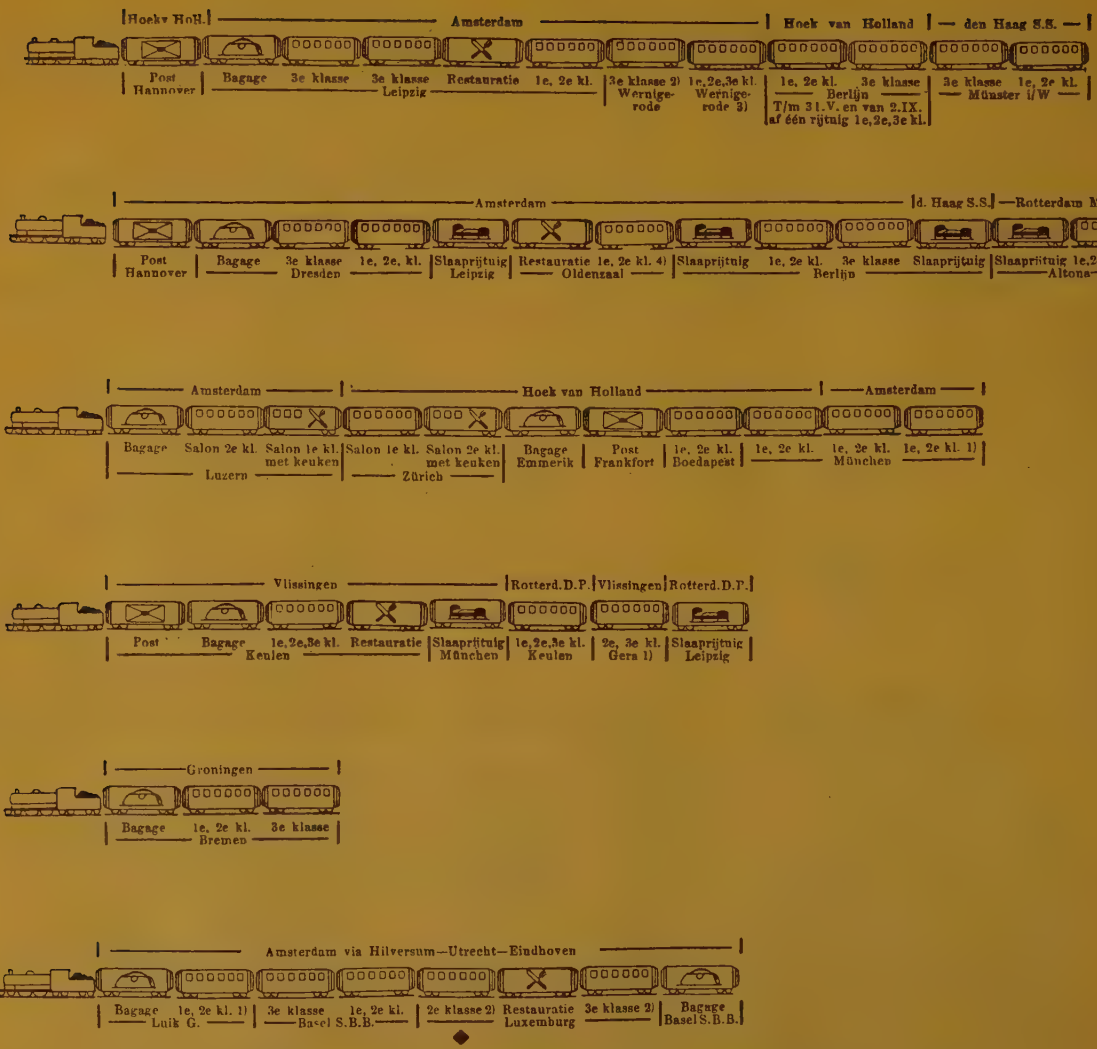


Fig. 151 — showing how some Dutch trains serving « conjugated » railway centres are made up.

D 171. — Germany day express, via Hengelo.
D 173. — Germany night express, via Hengelo.
D 271. — Switzerland and Southern Cermany express, via Zevenaar-Emmerich.
D 78. — Southern Germany night express via Venlo.
3250. — Bremen express, via Nieuwerschans.
D 196. — Switzerland express. via Liége-Luxemburg.

Fig. 152. — Cartogram of Dutch train speeds over all the lines of the system (except tramway lines).

Legend:
- Over 80 km. (50 miles) per hour.
- 70 to 80 km. (43.5 to 50 miles) per hour.
- 60 to 70 km. (37.3 to 43.5 miles) per hour.
- Under 60 km. (37.3 miles) per hour.

Fig. 153. — Cartogram showing the routes followed by the boat trains.

Certain night goods trains with few stops, such as those from Amsterdam C. S. to Maastricht (7041/42) or from Rotterdam D. P. to Groningen (7045/46) also carry parcels and even passengers.

On the other hand, the working of the Limburg coal mines has created an important traffic current, whose trains are hauled by 4-8-4 tank engines which rank among the most powerful in Europe (1). In view of the fact that they must always be able to develop the same tractive power and have the same adhesive weight, the water tanks and the coal bunkers have been placed behind the driver's cab over a trailing bogie.

XXVII-8. — **Dutch sleeping-car and restaurant-car services** (fig. 154). — As in other countries adjoining Germany, certain German services of the *Mitropa* supplement in Holland those of the *International Sleeping-Car Co.* They operate the services between Holland and Germany, and those between Holland, Germany and Switzerland.

TABLE 153.

DUTCH SERVICES OF THE MITROPA AND OF THE INTERNATIONAL SLEEPING-CAR Co.

KIND OF CARRIAGES.	Service.	Company.	
		Mitropa.	Sl. Car. Co.
Sleeping cars	Home.	...	4
	International.	16	6
Dining cars	Home.	...	22
	International.	20	6
Saloon or Pullman cars	Home.	...	2
	International.	2	...
« De luxe » trains	Home.	...	...
	International.	2	4

The *Sleeping-Car Co.* runs Pullman trains in Holland, whereas a rake is detached on the way from the Berlin or Ostend « de luxe » trains.

(1) The following are some other locomotives of the same type, in service when this locomotive was designed :

COMPANY.	Weight in working order.	Total wheel base.	Tractive force.
North of Spain	99.2 t. (97.6 Engl. tons)	12.750 m. (41 ft. 10 in.)	13.8 t. (13.6 Engl. tons)
Madrid, Saragossa & Alicante	110.0 t. (108.3 Engl. tons)	12.800 m. (45 ft. 3 7/16 in.)	13.3 t. (13.1 Engl. tons)
Paris-Lyons-Mediterranean	118.3 t. (116.4 Engl. tons)	14.360 m. (47 ft. 2 3/8 in.)	14.1 t. (13.9 Engl. tons)
Alsace-Lorraine	123.3 t. (121.3 Engl. tons)	14.360 m. (47 ft. 2 3/8 in.)	14.2 t. (14.0 Engl. tons)
Netherlands	126.4 t. (124.4 Engl. tons)	14.050 m. (46 ft. 2 5/32 in.)	14.7 t. (14.5 Engl. tons)

Fig. 154. — Cartogram showing the routes followed in Holland by the sleeping-car, dining-car, and Pullman trains and services.

Sleeping-Car Co. and Mitropa.

Services between Holland and Switzerland. — In June 1901, a series of trains was introduced towards Switzerland which, until then, was only directly connected with London via Calais. The « Amsterdam Switzerland Express » which belonged to this series started both from Amsterdam and The Hague, the two portions joining up in Utrecht; it then ran through Emmerich and along the left bank of the Rhine, picking up at Basle coaches from Paris, Calais, and Berlin (1) for Coire. Although these trains were discontinued after half a dozen years, other important trains have since connected Holland with Switzerland.

The *Mitropa* introduced, in 1928, a sleeping-car train from Berlin and Holland to Basle, where it split up into four sections which ran to Coire, Lugano, Interlaken and Geneva respectively.

Two saloon trains, one belonging to the *Sleeping-Car Co.* (the « Edelweiss ») and the other to the *Mitropa* (the « Rheingold ») make the same run by day. It is interesting to note that parts of these competing expresses are run in the same trains beyond Basle.

BOOKED TIMES OF THE « EDELWEISS » AND THE « RHEINGOLD ».

Train.	Destination.		Distance.		Direction.	
			Km.	Miles.	Outward	Return
Edelweiss	Basle.	Swiss Federal.	817	508	10 h. 40	11 h. 09
Rheingold (2) . . .	Do.	Do.	781	485	10 h. 47	10 h. 40
Do. . . .	Do.	Bad. Bhf.	777	483	10 h. 28	10 h. 18

Competition also exists in the first part of the run, as the trains from Amsterdam to Luxemburg run either via Roosendaal and Brussels (« Edelweiss »), or via Maastricht and Liége. This latter route is shorter than the former by some 30 km. (18.6 miles), but the trains take an hour more. It has 60 km. (37.3 miles) more in Holland than has the Brussels route (Cf. p. 166/306).

Relations with the South and Near East were covered by rakes from Amsterdam or The Hague, which were attached to the « Lloyd Express », the « Riviera Express » and the « Ostend-Vienna-Orient », the latter being the only one of the three which has been reintroduced since the war : the Amsterdam rake joins the Ostend train at Cologne.

Services between Holland and France. — In 1900, an « Amsterdam-Mons Express », the embryo of the present-day Pullman trains, was introduced. This was an *S.S.* train including rakes from

(1) It took 13 h. 50 m. from Amsterdam to Basle, and 18 h. 44 m. to Coire, where the *Rhaetic Railway* took on the train by a connection to Thusis, which was the terminus at the time (1901).

(2) The « Rheingold » also has a rake for the Hook of Holland.

Table 154.

DUTCH SERVICES OF THE INTERNATIONAL SLEEPING-CAR Co. AND THE MITROPA.

Discontinued services are shown *in italics*.

Company.	NAME OF TRAIN.	RUN.	Distance. Km.	Distance. Miles.	Time spent.
	« De luxe » trains.				
Sl. Car. Co.	Ostend-Vienna-Orient . .	Amsterdam-Cologne-Bucharest.	2240	1392	R40.46
Sl. Car. Co.	*Amsterdam-Switzerl. Exp.* . .	*Amsterdam* } *Cologne-Basle-Coire* (1).	987	613	*20.09*
	Do.	*The Hague* }	1007	625	*20.44*
Sl. Car. Co.	*Lloyd Express*	*Amsterdam-Basle-Gothard-Genoa.*	1354	842	*25.25*
Sl. Car. Co.	*Riviera Express*	*Amsterdam* } *Strasbourg-Lyons.*	2080	1293	*29.14*
		The Hague } *Ventimiglia.*	2057	1278	*29.36*
Sl. Car. Co.	*Amsterdam-Mons Express* .	*Amsterdam* } *Gouda-Mons* (2).	298	185	*5.55*
		The Hague }	275	171	*5.38*
Sl. Car. Co.	Etoile du Nord	Amsterdam (3)-Bruss. M.-Paris N.	539	335	6.5
Sl. Car. Co.	Edelweiss	Amsterdam-Bruss. Q. L.-Basle-Zurich.	910	565	13.24
		Amsterdam-Bruss. Q. L.-Basle-Lucerne.	916	569	
Mitropa	Rheingold	Amsterdam (1)-Cologne-Basle-Zurich.	869	540	12.31
		Amsterdam-Cologne-Basle-Lucerne.	877	545	12.52
		Hook of Holland-Basle-Zurich.	918	570	13.24
Mitropa	*All-sleeping-car train* . .	*Amsterdam-Basle-Coire.*	987	613	*20.44*
		The Hague-Basle-Interlaken.	886	551	*20.21*
	Sleeping-car services.				
Sl. Car. Co.	Amsterdam	Brussels Midi-Paris Nord.	546	339	10.40
	Do.	Maastricht-Basle.	785	488	13.12
	Do.	Maastricht.	222	138	...
Sl. Car. Co.	The Hague	Brussels Q. L.-Basle-Rome.	2047	1247	34.28
	Sleeping-cars to Germany.				
Mitropa	Amsterdam	Bentheim-Berlin.	646	402	11.1
	The Hague		684	425	11.9
	Flushing		770	478	13 1
Mitropa	Amsterdam	Bentheim-Leipzig.	654	406	12.1
	Flushing		777	483	14.2
Mitropa	Rotterdam-Maas	Bentheim-Hamburg-Altona.	524	325	10.9
	Flushing		618	384	12.9
Mitropa	Amsterdam	Emmerich-Cologne-Würzburg.	630	391	12.7
Mitropa	Flushing	Emmerich-Cologne-Munich.	935	581	16.1
Mitropa	Rotterdam D. P.	Viersen-Cassel-Leipzig.	756	470	14.3
	Sleep. cars to Switzerland.				
Mitropa	Amsterdam	Cologne-Basle-Coire.	981	610	17.6
			1027	638	20.6
Mitropa	Amsterdam	Cologne-Basle-Interlaken.	941	585	17 1
			1018	632	20.0
	Saloon-car services.				
Sl. Car. Co.	Amsterdam-Flushing . . .	Flushing.	219	136	3.7
Mitropa	Hook of Holland	Berlin.	646	402	10.7

(1) From Amsterdam, Central Station, to Amsterdam W. P., 5.704 km. (3.15 miles) by the circle line, and to Amsterdam P. M., 3.456 km. (2.14 miles).

(2) From Amsterdam, The Hague and Gouda to Utrecht Maas and thence to the Delftsche Poort station by the circle line : 14.714 km. (9.1 miles).

(3) The line from Amsterdam to Rotterdam via the Hague is 9 km. (5.6 miles) shorter than that via Gouda.

Amsterdam and The Hague, which joined up at Gouda (1). It was hoped that the *Nord* Company would extend the run as far as Paris, but nothing was done, and the train was discontinued after four or five years.

It was reintroduced after the war as a Pullman train, the « Etoile du Nord », from Paris to Amsterdam, over the former Dutch *H.S.* line, via The Hague.

The « Rotterdam Lloyd Express » which runs twice each month belongs to the railway companies.

CHAPTER XXVIII.

The speeds.

XXVIII-1. — **General.** — Some information concerning the electrified lines and rail motor coach services will be given before dealing with the speeds, as it is advisable to make a distinction between the various methods of traction used on the different parts of the system.

TOWNS OF SECONDARY IMPORTANCE. — Owing to the way the country is split up by waterways, certain towns which are really not very far apart are connected by relatively roundabout railway routes, such as those from Leeuwarden to Amsterdam, and from Rotterdam to Flushing. Their importance as secondary centres is therefore growing.

On the other hand, whereas Utrecht, for example, is on the direct line from Rotterdam to The Hague, it is also the point at which many of the international (German) trains split up so as to send rakes to the three « conjugated » towns : Amsterdam, The Hague and Rotterdam. This is therefore the real railway centre of the country. For these and other reasons, the Dutch towns are more important from the railway point of view than Belgian towns of equal size.

To this must be added an operating reason. As in Germany, the coaches — and not the passengers — change trains for important destinations and the trains are nearly always formed of several sections coming from different places and going to various others. All large stations are thus marshalling ones and not merely through stations.

Figure 151 shows the composition of a certain number of international trains as usually formed, but the same applies to most of the important home trains.

XXVIII-2. — **The electric services** (fig. 156). — The Netherlands Railways have electrified 198 km. (123 miles) of line :

Amsterdam-Haarlem-Rotterdam-Dordrecht . .	106 km.	(65.9 miles).
(Rotterdam) Schiedam-Hook of Holland . .	23 —	(14.3 —).
Haarlem-Zandvoort	9 —	(5.6 —).
Amsterdam-Alkmaar	39 —	(24.2 —).
(Alkmaar) Uitgeest-Haarlem	18 —	(11.2 —)
Ymuiden branch	3 —	(1.86 —).

(1) This train took 4 h. 39 m. from Amsterdam to Brussels Midi, including four stops, among them one at the frontier and another at the Antwerp Central terminus. It took 5 h. 43 m. to get to Mons.
The return journey took 5 h. 15 m. from Mons, and 4 h. 11 m. from Brussels.
Since that time, half an hour has been saved on the total run.
The supplementary charge from Amsterdam to Brussels was 6.90 francs.

These are served by trains generally running at half-hour, and sometimes at quarter of an hour intervals. Their running speed is 100 km. (62 miles) an hour (1) and their overall speed is very high (table 152).

Heavy trains, such as international expresses and others, are still hauled by steam locomotives (2) over the electrified sections.

XXVIII-3. — **Services by rail motor coaches and trains.** — For several years, the Netherlands Railways have been carrying out a series of tests on bogie petrol vehicles of two different types, one with a 115-H.P. engine, and the other 75 H.P., their weights being 45 and 36 tons respectively. These vehicles worked over the following lines :

Groningen-Delftzijl . .	42 km.	26 miles.
Zwolle-Kempen . . .	14 km.	9 miles.

Although, on account of the absence of gradients, Holland is an ideal country for steam locomotives, and although important and carefully selected lines have been electrified, diesel-electric vehicles have been preferred for the various lines radiating from Utrecht (255 km. = 158.4 miles) :

Utrecht-Amsterdam W. P.	35 km.	(21.7 miles).
Do. -The Hague S. S.	61 —	(37.9 —).
Do. -Rotterdam Maas i.e., from Gouda . .	21 —	(13.0 —).
Do. -Arnhem	57 —	(35.4 —).
Do. -Eindhoven	81 —	(50.3 —).

Consequently 40 triplet sets were ordered, which could be coupled together. The actual running speed is 100 km. (62 miles) an hour; these rail motor coaches can reach 140 km. (87 miles) an hour on the level. It is interesting to note that had they not been streamlined they could not have exceeded 100 km. (62 miles) an hour, whereas in fact they are able to run at this speed using only one of their two engines.

Their weight is the same as the twin-unit German vehicles (75 tons) although their length has been increased from 42 to 62 m. (137 ft. 9 in. to 203 ft. 5 in.). Consequently the weight per lineal metre is 1.2 tons, while it is 2.7 for the ordinary passenger trains, and 2.4 for the electric trains made up of 5 vehicles.

Eighteen sets were put into service on the 15th May, 1934 (3), to the same timings as those of the steam trains.

The introduction of these Dutch services is important in view of the comparisons to be made between them and the same Company's electric services (fig. 156). In Holland, as in Belgium, the noise while running and the so-called insufficient stability of these vehicles has been criticised. A journey in one of them will convince anyone that such criticisms are uncalled for, but other points, including the technical formation of special staff, require most careful consideration.

In view of the way such services are being extended at the present time, it is interesting to show them in diagram

(1) At the end of 1932 the speed was 95 km. (59 miles) an hour in the case of the Amsterdam-Rotterdam line, and 90 km. (56 miles) an hour for the Amsterdam-Alkmaar and Haarlem-Uitgeest lines.

(2) They are shown on the timetable by the letter S (*stoom*).

(3) These services are shown in the timetables by the letters EM.

TABLE 155.

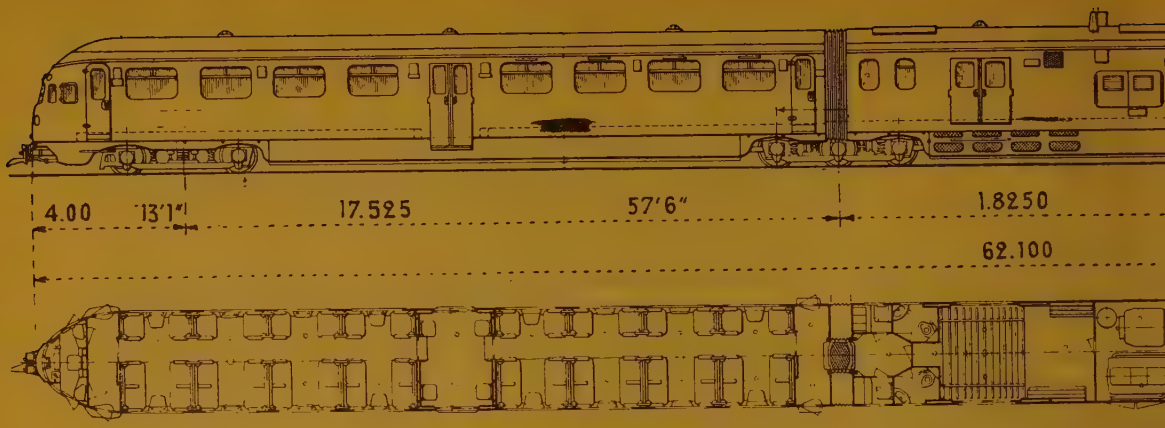
SERVICES OPERATED BY ELECTRIC VEHICLES, PETROL RAILCARS, AND DIESEL TRAINS AND RAILCARS.

The corresponding steam services are shown in italics.

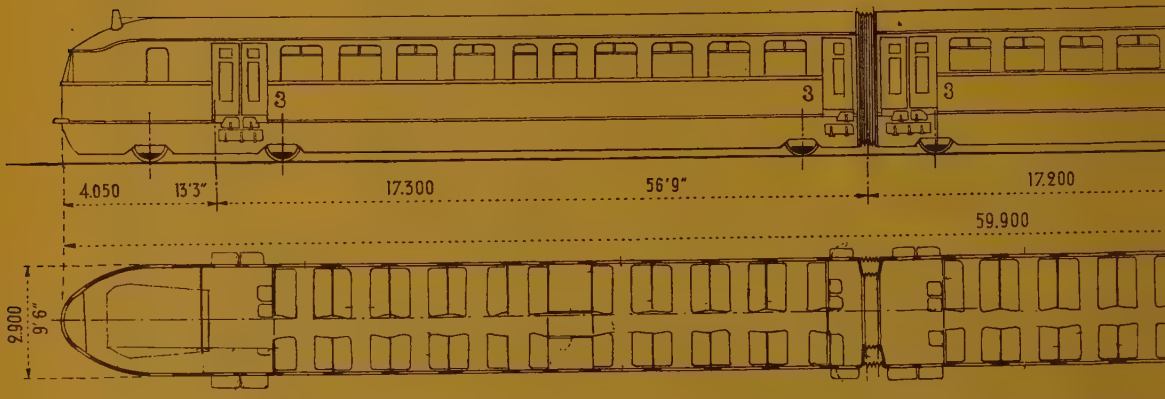
Non-stop runs in **heavy type.**

RUNS.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Stops. Number.	Stops. Minutes.	Speed. Km./h.	Speed. Miles/h.	—
Electric services.									
Amsterdam C. S.-Rotterd.-Dordrecht.	106	66	7.45 a. m.	1.36	7	13	66.3	41.2	
Amsterdam-Rotterdam D. P.	86	53	7.45 a. m.	1.14	5	8	69.7	43.3	
			12.55 p. m.	*1.10*	*1*	*2*	*73.7*	*45.8*	Pullman.
Amsterdam-Haarlem	19	12	**7.45** a. m.	**0.14**	—	—	**81.5**	**50.7**	
Haarlem-Leiden	29	18	**8.01** a. m.	**0.20**	—	—	**87.4**	**54.3**	
Leiden-The Hague	15	9	**8.23** a. m.	**0.11**	—	—	**81.8**	**50.8**	
Delft-Rotterdam	10	6	**8.59** a. m.	**0.12**	—	—	**50.0**	**31.1**	
Rotterdam D. P.-Dordrecht.	20	12	**9.07** a. m.	**0.14**	—	—	**85.7**	**53.2**	
	21	13	*1.23* p. m.	*0.17*	—	—	**70.6**	**43.8**	
Amsterdam C. S.-Alkmaar	39	24	*8.19* a. m.	*0.33*	—	—	*70.9*	*44.1*	
			1.30 p. m.	0.31	1	2	75.5	46.9	
Amsterdam-Uitgeest	23	14	**1.30** p. m.	**0.17**	—	—	**81.2**	**50.4**	
Uitgeest-Alkmaar	16	10	**1.49** p. m.	**0.12**	—	—	**80.0**	**49.7**	
Zaandam-Castricum	17	11	**8.40** a. m.	**0.13**	—	—	**78.4**	**48.7**	
Haarlem-Uitgeest	18	11	7.03 a. m.	0.17	2	2	63.5	39.4	
Haarlem-Velsen-Ymuiden	9	6	**7.03** a. m.	**0.08**	—	—	**65.5**	**40.7**	
Rotterd.-Pijnacker-The Hague H. S.	24	15	**7.15** a. m.	**0.24**	(1)	—	**60.0**	**37.3**	
Do. - Do. -Scheveningen K.	29	18	**7.51** a. m.	**0.27**	(1)	—	**64.5**	**40.1**	
Petrol railcars									
Flushing-Goes-Kruiningen	37	23	7.04 a. m.	1.01	6	8	36.4	22.6	
			6.15 a. m.	*0.59*	*6*	*8*	37.6	23.4	
Almelo-Hengelo-Oldenzaal	14	9	**5.32** a. m.	**0.13**	—	—	**64.6**	**43.5**	
Zwolle-Kampen	25	16	3.30 p. m.	0.40	3	7	37.5	23.6	
			2.15 p. m.	*0.40*	*2*	*9*	37.5	23.6	
Enschede-Gronau	9	6	6.28 a. m.	0.14	2	2	44.8	27 8	
Dieren-Apeldoorn-Zwolle	65	40	1.30 p. m.	1.32	10	14	42.4	26.3	
Zwolle-Almedo-Hengelo-Enschede	63	39	9.12 a. m.	1.16	12	14	49.7	30.8	
Meppel-Groningen	77	48	9.37 a. m.	1.31	9	10	50.8	31.6	
			3.16 p. m.	*1.46*	*8*	*9*	43.6	30.4	
Groningen-Delftzijl	42	26	8.40 a. m.	1.10	15	16	36.0	22.4	
Zwolle-Coevorden-Emmen	76	47	R 12.01 p. m.	1.45	12	17	43.4	26.9	
Diesel trains or railcars.									
Utrecht C. S.-Gouda-The Hague	61	38	10.00 a. m.	0.51	3	3	72.0	44.7	
			9.48 a. m.	*0.52*	*1*	*2*	*70.4*	*43.7*	D train.
			10.11 p. m.	*0.48*	—	—	*76.2*	*47.3*	
Utrecht-Gouda	33	21	**6.36** p. m.	**0.25**	—	—	**79.2**		

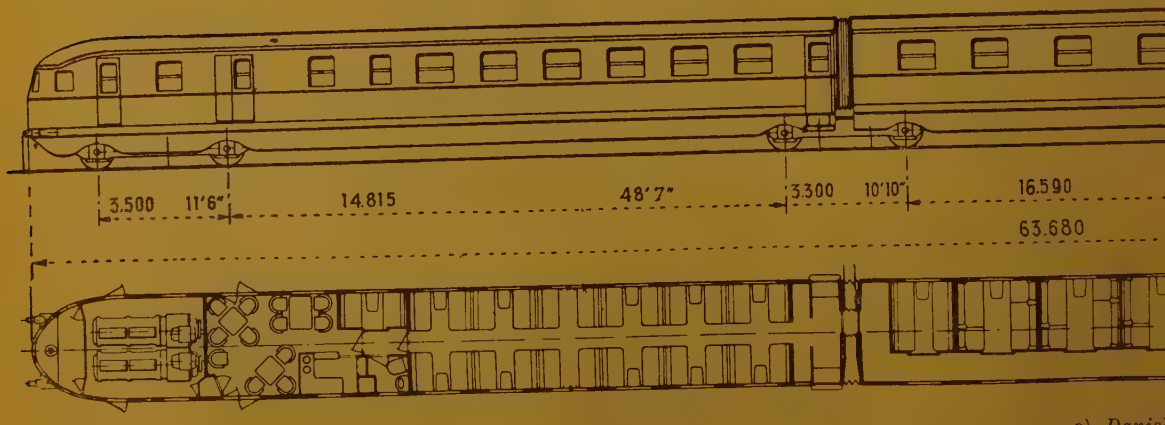
(This table is continued on p. 298/386.)



a)

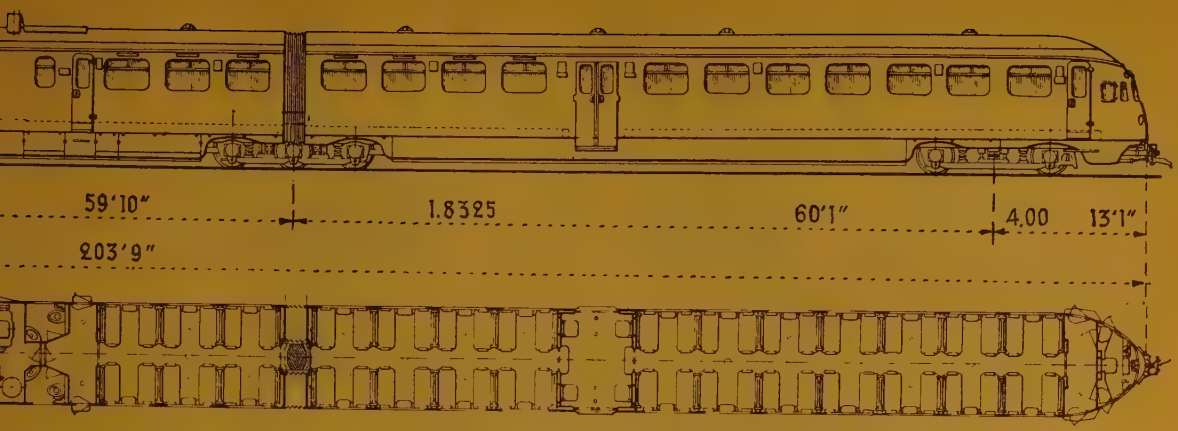


b) *Belgian National Railways*

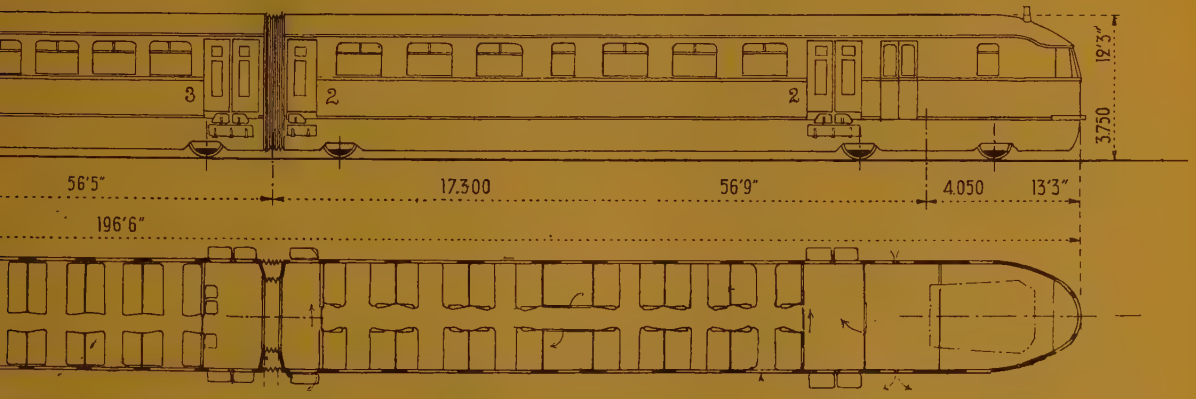


c) *Danis*

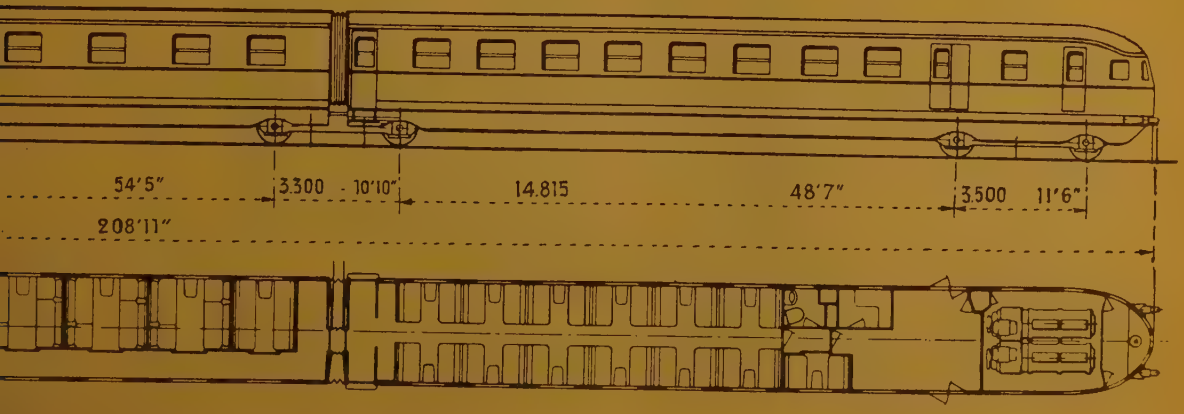
Fig. 155. — High-speed diesel-electri



train.



y's train (under construction).



ailways' train.

ted triple-car trains *(see also fig. 157).*

TABLE 155 (*continued*).

RUNS.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Stops. Number.	Stops. Minutes.	Speed. Km./h.	Speed. Miles/h	—
Diesel trains or railcars (*con'inued*).									
Utrecht C. S.-Gouda-The Hague S. S.	61	38	10.00 a. m.	0.51	3	3	72.0	44.7	
			9.48 a. m.	*0.52*	*1*	*2*	*70.4*	*43.7*	D 174
			10.11 p. m.	*0.48*	—	—	*76.2*	*47.3*	D 292
Utrecht-Gouda	33	21	6.36 p. m.	0.25	—	—	79.2	49.2	
			7.50 p. m.	*0.28*	—	—	*70.7*	*43.9*	D 172
	29	18	7.03 p. m.	0 24	—	—	72.5	45.0	
			8.20 p. m.	*0.24*	—	—	*72.5*	*45.0*	D 172
Utrecht C. S.-Gouda-Rotterdam M. .	53	33	6.36 p m.	0.54	1	7	50.9	31.7	
			4.21 p. m.	*0.52*	*1*	*2*	*61.1*	*38.0*	D 284
Gouda-Rotterdam Maas	20	12	10.08 a. m.	0.23	—	—	52.2	32.4	
			4 50 p. m.	*0.23*	—	—	*52.2*	*32.4*	D 284
Eindhoven-Utrecht-The Hague . . .	142	88	8.40 a. m.	2.11	9	18	65.0	40.4	
Eindhoven-Utrecht C. S.	81	50	8.40 a. m.	1.13	5	8	66.6	41.4	
			6.56 p. m.	*1.09*	*1*	*3*	*70.4*	*43.7*	
Eindhoven-Boxtel	20	12	8.40 a. m.	0.15	—	—	80.0	49.7	
Boxtel-s'Hertogenbosch	12	8	8.56 a. m.	0.10	—	—	72.0	44.7	
Culemborg-Utrecht S. S.	18	11	9.39 a. m.	0.14	—	—	77.1	47.9	
Eindhoven-s'Hertogenbosch	12	8	8.40 a. m.	0.26	1	1	73.8	45.9	
			2.34 p. m.	*0.27*	—	—	*71.1*	*44.2*	
s'Hertogenbosch-Utrecht C. S. . .	49	30	9.09 a. m.	0.44	3	4	66.8	41.5	
			7.26 p. m.	*0 39*	—	—	*75.4*	*46.8*	
Arnhem-Utrecht C. S.-Amsterd. W. P.	92	57	11.08 a. m.	1.15	3	6	73.6	45.8	
			2.36 p. m.	*1.11*	*1*	*2*	*77.5*	*48.1*	
Arhem-Ede	16	10	11.08 a. m.	0.13	—	—	73.8	45.9	
Ede-Driebergen	29	18	11.22 a. m.	0.20	—	—	87.0	54.1	
Driebergen-Utrecht C. S.	11	7	11.43 a. m.	0.10	—	—	66.0	41.0	
Arnhem-Utrecht	8	35	11.08 a. m.	0.45	2	2	74.7	46.4	
			2.36 p. m.	*0.42*	—	—	*71.0*	*44.1*	
Utrecht C. S.-Amsterdam W. P. .	36	22	11.57 a. m.	0.26	—	—	83.1	51.6	
			3.20 p. m.	*0.27*	—	—	*80.0*	*49.7*	

form, and compare them with those of other administrations (figs. 155 and 157).

We will give similar information concerning twin-unit motor coaches when dealing with the German services.

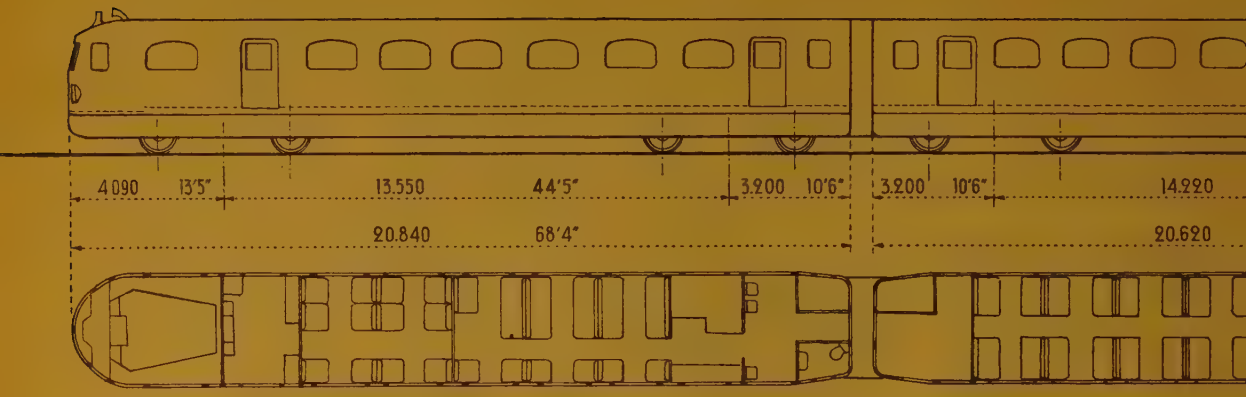
XXVIII-4. — There are many interesting train runs in Holland as, apart from their own value, comparisons between different methods of traction — electric traction, steam traction, or rail motor coaches — is possible.

Up to the present, the short-distance fast services have been reserved for electric coaches and rail motor cars, and steam traction has been retained in the case of heavy trains as well as for journeys of some length, even over lines where other methods of traction are used or can be.

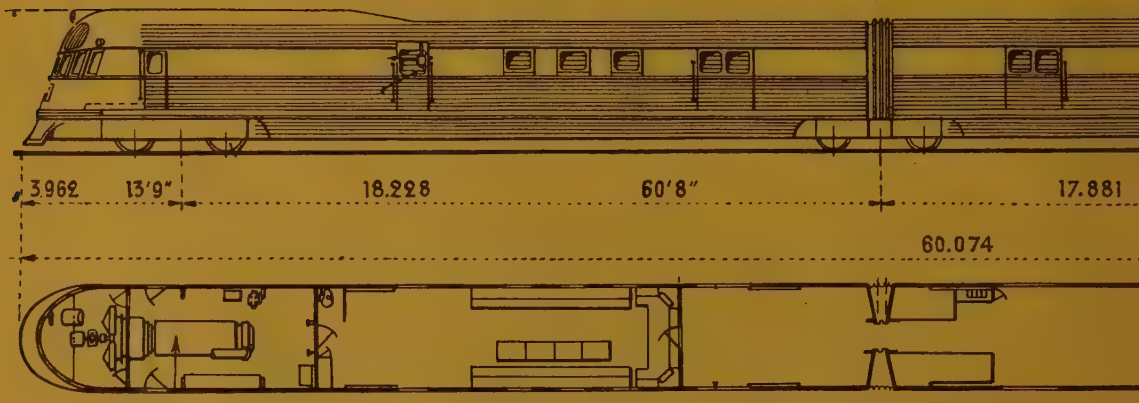
When it will have more experience, as it will in the near future, the Dutch Administration may be expected to extend one or other method of traction. It may also use electric locomotives to haul main-

Fig. 156*a*. — Cartogram showing the Dutch services operated by fast diesel rail motor coaches and by electric traction.

Fig. 156*b*. — Cartogram showing the steam services on lines also run over by fast diesel rail motor coaches or electric trains.



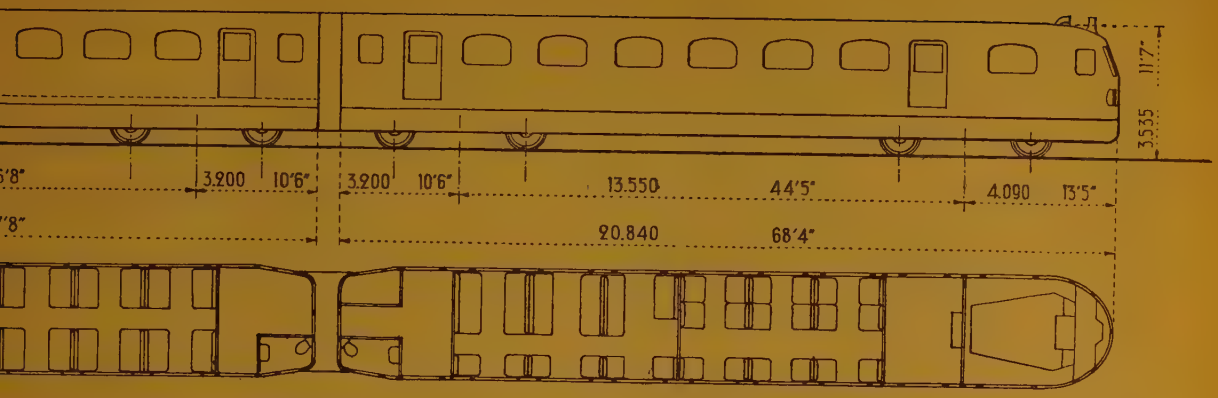
d) *Triple-car non-articulat*



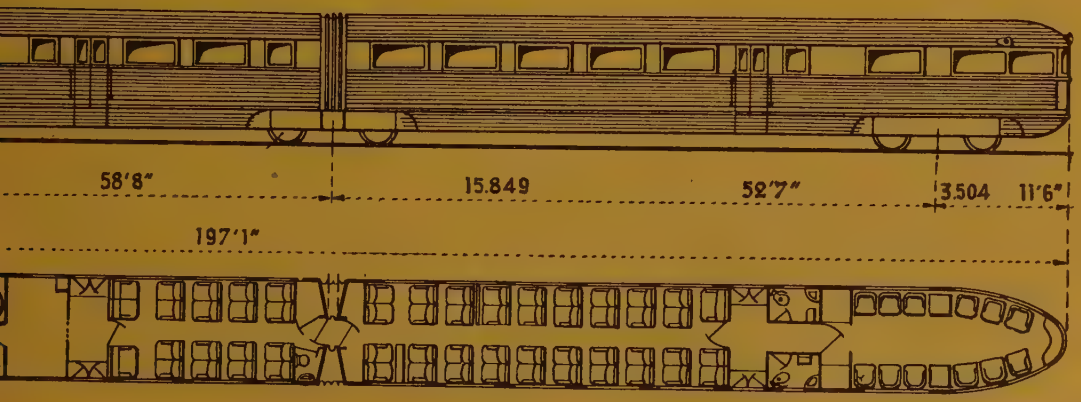
e) *The* « Zephyr », *Chicago, Bu*

f) *The Union Pacific Rail*

Fig. 157. — Triple-car diesel



of the Nord Ry., France.



& Pacific R. R. (U. S. A.).

. S. A.) triple unit.

trains for fast services.

Table 156.

INTERESTING DUTCH TRAIN RUNS (Fig. 152).

Non-stop runs are shown in **heavy type**; discontinued trains in *italics*.

RUN.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. Miles/h.	Remarks and number of stops.	Train.
Amsterdam-Rotterdam-Roosendaal	144	89.5	12.55 p. m.	2.00	72.0	44.7	2 stops.	Paris.
Amsterdam-The Hague	63	39.1	12.55 p. m.	0.47	80.4	50.0		
The Hague-Rotterdam	23	14.3	R7.50 a. m.	0.20	69.0	42.9		
Rotterdam-Roosendaal	58	36 0	2.08 p. m.	0.47	74.0	45.9		
Rotterdam-The Hague	24	14.9	7.15 a. m.	0.24	60.0	37 3	1 conditional stop.	
Rotterdam-Scheveningen	29	18.0	7.51 a. m.	0.27	64.5	40.1	Do.	
Amsterdam-Utrecht-Maastricht	228	141.7	9.05 a. m.	3.23	67.4	41.9	5 stops.	D 196
Utrecht-s'Hertogenbosch	49	30.4	9.53 a. m.	0.39	75.4	46.9		
Eindhoven-Roermond	53	32.9	R1.32 p. m.	0.42	73.5	45.7		D 196
Amsterdam-Nijmegen (Kleef)	117	72.7	R12.09 p. m.	1.42	68.8	42.8		
Rotterdam-Gouda-Utrecht-Arnhem-Nijmegen	139	86.4	10.34 a. m.	2.08	60.5	37.6		
(Dordrecht) Kesteren-Nijmegen (Kleef).								
Kesteren-Nijmegen	25	15.5	R9.05 a. m.	0.21	71.4	44 4		
Tiel-Nijmegen	37	23.0	R9.31 a. m.	0.28	79.3	49.3		
Amsterdam-Utrecht-Arnhem-Zevenaar	112	69 6	2.52 p. m.	1.41	66.5	41.3	2 stops.	D 283
Amsterdam-Utrecht	41	25.5	2.52 p. m.	0.33	71.5	44.4		
Utrecht-Arnhem	57	35 4	R6.57 p. m.	0.42	81.4	50.6		D 280
Rotterdam-Gouda-Utrecht-Zevenaar	124	77.1	7.33 a. m.	2.14	55.5	34.5	3 stops.	D 271
The Hague-Gouda-Utrecht-Zevenaar	132	82.0	2.23 p. m.	2.10	60.9	37.8		283
Amsterdam-Amersfoort-Hengelo	151	93.8	8.44 a. m.	2.17	66.1	41.1		D 111
Amsterdam-Amersfoort	45	28.0	8.44 a. m.	0.38	71.1	44.2		
Amersfoort-Apeldoorn	44	27.3	12.21 p. m.	0.35	75.4	46.9		D 171
Do. -Hengelo	112	69.6	9.31 a. m.	1.30	74.7	46.4		
Hook of Holland-Rotterd.-Utrecht-Hengelo	223	138.6	7.25 a. m.	3.36	61.9	38.5		D 111
Amsterdam-Amersfoort-Zwolle-Groningen	217	134.8	1.32 p. m.	3.08	69.2	43.0		
The Hague-Utrecht-Amersfoort-Zwolle-Groningen	247	153 5	*12.50* p. m.	*3.50*	*64.4*	*40.0*		
The Hague-Utrecht	61	37.9	R10.11 p. m.	0.48	76.2	47.3		D 292
Rotterdam-Utrecht	53	32.9	R10.05 p. m.	0.55	57.9	36.0		D 112
Utrecht-Amersfoort	45	28.0	8.44 a. m.	0.38	71.1	44.2		D 111
Amersfoort-Zwolle	67	41.6	2.18 p. m.	0.53	75.8	47.1		
Zwolle-Groningen	105	65.3	3.18 p. m.	1.22	76.8	47.7		
Do. -Assen	77	47.8	R1.03 p. m.	0.56	82.5	51.3	Saturday.	
Amsterdam-Alkmaar-Helder	81	50.3	5.17 p. m.	1.16	63.9	39.7	3 stops.	
Amsterdam-Alkmaar	39	24.2	5.17 p. m.	0.29	80.8	50.2		
Heer-Hugowaard-Hoorn	17	10.6	1.47 p. m.	0.15	68.0	42.3		

TABLE 157.

THE FASTEST DUTCH RUNS.

[Over 75 km. (46.6 miles) per hour overall speed.]

RUN.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. Miles/h.	—
Electric traction.							
(Amst.) Haarlem-Leiden	29	18	8.01 a. m.	0.20	87.4	54.3	
(Amst.) Rotterdam B.-Dordrecht	20	12	9.07 a. m.	0.14	85.7	53.2	
(Amst.) Leiden-The Hague	15	9	8.23 a. m.	0.11	81.8	50.8	
Amsterdam-Haarlem	19	12	7.45 a. m.	0.14	81.5	50.7	
Amsterdam-Uitgeest (Alkmaar)	23	14	1.30 p. m.	0.17	81.2	50.4	
(Amst.) Uitgeest-Alkmaar	16	10	1.49 p. m.	0.12	80.0	49.7	
Railcars.							
(Arnhem) Ede-Driebergen	29	18	11.22 a. m.	0.20	87.0	54.1	
Utrecht C. S.-Amsterdam W. P.	36	22	11.57 a. m.	0.26	83.1	51.6	
Eindhoven-Boxtel	20	12	8.40 a. m.	0.15	80.0	49.7	
Utrecht-Gouda (The Hague)	33	21	6.36 p. m.	0.25	79.2	49.2	
(Eindh.) Culemborg-Utrecht S. S.	18	11	9.39 a. m.	0.14	77.1	47.9	
Steam traction.							*In 1914.*
Flushing-Roosendaal (Amst.)	85	53	*4.45* p. m.	*1.00*	*85*	*52.8*	*Boat train.*
Amsterdam-Rotterdam	77	48	*8.30* a. m.	*0.55*	*84.0*	*52.2*	*In 1914.*
Flushing-Roosendaal (Amst.)	75	47	12.43 p. m.	0.54	83.3	51.8	*Boat train.*
Rotterdam-Esschen	66	41	*3.59* p. m.	*0.49*	*82.6*	*53.1*	*In 1914.*
(Groningen) Assen-Zwolle	77	48	1.03 p. m.	0.56	82.5	51.3	
(Amsterdam) Utrecht-Arnhem	57	35	R 6.57 p. m.	0 42	81 4	50 5	D 280
Hengelo-Zutphen	46	29	8.15 a. m.	0.34	81.2	50.4	D 138
Amsterdam-Alkmaar (Helder)	39	24	5.17 p. m.	0.29	80.8	50.2	
Amsterdam-The Hague	63	39	12.55 p. m.	0.47	80.4	49.9	
(Flushing) Eindhoven-Venlo	52	32	R 10.43 p. m.	0.39	80.0	49.7	Boat train.
Utrecht C. S.-Amsterdam W. P.	36	22	3.20 p. m.	0.27	80.0	49.7	
(Groningen) Assen-Meppel	49	30	9.07 a. m.	0.37	79 5	49.4	
Nijmegen-Tiel (Dordrecht)	37	23	9.31 a. m.	0.28	79.3	49.3	
Flushing-Boxtel-Eindhoven	153	95	6.16 p. m.	2.00	76.5	47.5	Boat train.
Utrecht C. S.-The Hague	61	38	10.11 p. m.	0.48	76.2	47.3	
Amersfoort-Apeldoorn	44	27	12.21 p. m.	0.35	75.4	46.8	
s'Hertogenbosch-Utrecht (Hague)	49	30	7.26 p. m.	0.39	75.4	46.8	

TABLE 158.

THE LONGEST DUTCH NON-STOP RUNS.

RUN.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. Miles/h.	—
Flushing-Boxtel-Eindhoven	153	95.1	6.16 p. m.	2.00	76.5	47 5	Boat train.
Amsterdam-Amersfoort-Hengelo	151	93.8	8.44 a. m.	2.17	66.1	41.1	D 111 to Bentheim.
Amersfoort-Hengelo (Bentheim)	112	69.6	9.31 a. m.	1.30	74.7	46.4	
Zwolle-Groningen	105	65.3	3.18 p. m.	1.22	76.8	47.7	Saturdays only.
(Venlo) Eindhoven-Roosendaal	78	48.5	11.27 a. m.	1.08	68.8	42.8	
(Groningen) Assen-Zwolle	77	47.8	1.03 p. m.	0.56	82.5	51.3	
Flushing-Roosendaal	75	46.6	12.43 p. m.	0.54	83.3	51.8	

line and goods trains, instead of the present steam locomotives. The situation in Holland is therefore well worth following up.

XXVIII-5. — **Internal navigation.** — As communications of this sort supplement the railway services, we will deal with them briefly, though there are not very many of them in Holland.

The principal line of the kind is that from Stavoren to Enkhuizen, connecting with the Amsterdam and Leeuwarden trains. The speed of the boats is 24 km. (14.9 miles) an hour. The time allowed between the arrival of the train and the departure of the boat is 5 minutes and between the boat's arrival and the train's departure, 9 minutes. This information is interesting when considering ferry-boat services.

There are four daily crossings each way, each run in connection with trains from Amsterdam and from Alkmaar, at standardised timings.

For tariff purposes, the length of the crossing, as shown in the timetables, has been increased by 6 kilometres.

XXVIII-6. — **Conclusions.** — The proportion of fast lines is very large in Holland and the international services over them are often duplicated. The proportion of lines run over at various speeds is as follows (fig. 152) :

TABLE 159.

MILEAGE AND PROPORTION OF DUTCH LINES RUN OVER AT VARIOUS SPEEDS.

Mileage.	Speed.		Kilometres.	Percentage.
	Miles per hour.	Kilometres per hour.		
...	Over 62	Over 100	...	...
...	56 to 59.9	90 to 99.9	...	...
254	50 to 55.9	80 to 89.9	409	12.0
587	44 to 49.9	70 to 79.9	945	27.8
379	38 to 43.9	60 to 69.9	609	17.8
896	Under 38	Under 60	1 442	42.4
2 116	← TOTAL. →		3 405	100.0

(To be continued.)

[625. 143. 3]

Rails broken and damaged in service.

Present state of the question and improvements required,

by J. MERKLEN,

Honorary Chief Engineer, Permanent Way and Buildings, Alsace-Lorraine Railways,

and E. VALLOT,

Honorary Engineer, French State Railways.

(Le Génie Civil.)

The authors of this note, during many years' collaboration on the French former *Ouest* and the *State* Railways, have had occasion to record much information on the behaviour of metals in railway service, and in particular of metals used in the track or fixed plant.

These enquiries have led to certain interesting conclusions which we give below. These conclusions are based both on our own experience and also on the opinions of many investigators, metallurgists and engineers, considered as authorities on this matter.

Amongst these latter, we must mention in particular Charles Frémont, who died in Paris in 1930, and whose memory was celebrated with due ceremony last year at the house he formerly inhabited at Montmartre.

Charles Frémont, a man of great inventiveness of mind, devoted himself towards the end of the 19th century to developing rational test methods which would enable inspectors to reject defective metals and more especially brittle steels. As we entirely accepted the views of this «illustrious technician»(1), we obtained permission for him to carry out in the *Ouest* Railway Company's permanent way shops, and according to his methods, drop tests on short lengths of rail, the results of which he dealt with in a paper read on the 3rd January, 1903, before the Académie des Sciences, entitled « *Nouvelle méthode d'essai des rails* » (New methods of testing rails).

The tests themselves were completed by many investigations on rails broken in service, these investigations being made the subject of various pamphlets published by Charles Frémont in 1911(2) 1921, 1922 and 1924.

We followed very closely his brilliant researches on the « elastic strength » (commonly called resilience) (3), the

(1) See *Bulletin de la Société d'Encouragement pour l'Industrie nationale*, June 1931 : Article on *Charles Frémont* by Ed. SAUVAGE, Inspecteur Général des Mines : « The name of Frémont should be honoured as one of our illustrious technicians », page 376.

(2) See *Génie Civil* of the 6th, 13th, 20th and 27th May, 1911.

(3) Frémont pointed out in his 62nd pamphlet entitled « *Unification des méthodes d'essai des métaux* » (Standardisation of the methods of testing metals), page 35, that the expression « résilience » taken from the English was unsuitable, as it meant in English the « *live elastic limit* », the quantity of work expended to produce the total elastic deformation, that is to say before any permanent deformation occurs, and not the *live breaking strength*, i.e. the quantity of work required to break the part. He considered the expression « live breaking strength » should be used, or simply « live strength » as this is the only one to be measured.

tensile strength, and the bending strength of metals, as well as his experiments on their corrosion, carried out at the Mechadical Engineering Laboratories of the School of Mines, and described in a series of pamphlets issued between 1902 and 1929. These pamphlets are pleasant to read owing to their clear style, the precision of the demonstrations, and the wealth of illustrations (4).

The article on the accidental breakages of rails we published in the May, 1926, number of the *Revue Générale des Chemins de fer*, contained our first observations on the behaviour of rails in service and the conclusion we had formed therefrom that it was essential : 1. to eliminate piping; 2. to manufacture sound homogeneous metal; 3. to produce tough rails with a high elastic limit and also good resistance to wear. Since that time, further information has been collected, which will be given below in the order used in the May, 1926, article.

A. *Brittleness : Homogeneity.* — All the observations recorded since 1926 confirm the necessity of making rails from steel that is homogeneous and not brittle.

We recorded that the Belgian Railways specified, even at that date, micrographic and resilience tests for record purposes.

The micrographic tests carried out during the manufacture of all supplies of rails, before and after etching the polished surfaces, have shown the extent of the microcavities and blowholes resulting from badly made steel, and have revealed those to be considered dangerous. They also revealed structures with too coarse crystals, those over-heated through finishing rolling at too high a temperature, and finally those containing impurities, such as manganese sulphide, for example.

These documentary records have been a definite benefit to the user, as they have enabled him to draw the makers' attention to poor or defective materials. Premature wear and crushing of rails in the track have in particular become very rare, and *certain rails found defective in service have been replaced by the makers* as a result of these tests.

The resilience tests have been continued since, and as shown on a diagram in an article by Mr. Servais, in 1930 (5), the rails have continued to improve as regards their toughness; in 1929 more than 80 % of the rails tested had a minimum value exceeding 2 kgrm./cm² (93.3 ft.-lb. per sq. inch), and more than 65 % above 3 kgrm./cm² (140 ft.-lb. per sq. inch). Nonetheless, of the rails accepted 4.27 % had resilience values below 1 kgrm./cm² (46.65 ft.-lb. per sq. inch) and 13.15 % below 2 kgrm./cm²(4).

With these two last figures, low as they are, there are still possibilities of fracture which could be eliminated by replacing the tests made for record purposes by tests which must be passed before the rails are accepted. Messrs Cambournac and Patte, in their report to the Madrid Congress in 1930 (6), on the *Resistance of rails against breakage and to wear*, gave (pages 2042 et seq.) the results of resilience tests (Mesnager test piece, Charpy tup) and shock tests on notched rails carried out on 1.10-m. (3 ft. 7 5/16 in.) lengths of rail taken from three rail bars A, B, C, of different makes, and obtained by rolling three whole ingots into rails. From these tests they concluded that it is difficult to describe a cast, or even an ingot, as being

(4) See J. Servais, « Rails on the Belgian National Railways », Liége, International Congress, June 1930, Metallurgical section, page 397 A.

(5) See *Bulletin of the International Railway Congress Association*, June 1930, p. 1563.

(6) See *Bulletin of the International Railway Congress Association*, October 1929, page 2011.

free from brittleness, by the value of the resilience found from a point arbitrarily selected beforehand.

They considered that, in order to get a more constant result, the test should be made on the full-section rail and that the shock test on a notched rail, which is only an approximation, should be replaced by using « a testing machine of sufficient power to register, after fracture at the first blow, of a section of rail suitably notched, the kinetic energy remaining in the tup and from it to deduce, as with the Charpy pendulum, the resilience of the metal ».

As a first step in this direction, they suggested a new shape of notch, investigated by one of us, made with a fine saw 0.15 mm. (0.0059 inch) thick, to a depth of 1.5 mm. (0.059 inch). The authors of the report added it was desirable « to make sure by a complete series of tests on the whole length of the ingot rolled into rails, that the results were sufficiently constant from section to section to show the ingot was indeed free from brittleness. »

We understand that the *Italian State Railways* are about to introduce the drop test suggested by Messrs. Cambournac and Patte; instead of the fine saw cut which is difficult to make in practice they have obtained satisfactory results by using a saw 1 mm. (0.039 inch) thick. The graphs on pages 2044, 2045 and 2046 of Messrs. Cambournac and Patte's report « show that the resilience varies from one point to another of the same section and from one section to the following of the same bar. »

The diagram (fig. 29, page 2045) more especially indicates that the drop tests on small notched test pieces show the steel to be brittle in six areas of the bar rolled from one and the same ingot. As a matter of fact, the resiliences C (head), A (web) and P (foot) are all three very low in the sections lying at 25, 44, 56, 65, 70 and 75 % of the length of this rail, whereas this result has only been confirmed, by a drop test on a short notched length, in the case of the 40 % sectional area.

This observation shows that, instead of ascertaining the resilience of the metal in the full rail section, it is better, as a rule, to make resilience tests on small Mesnager test pieces, as the Belgian National Railways have been doing since 1923. Owing to their *localisation,* these tests enable the steel to be explored for brittleness at different points of a given section, and in other sections at little cost, and thereby reveal the degree of homogeneity of the metal. This latter condition can be obtained, to some extent at least, by reducing the temperature sufficiently at the end of the rolling, or by a suitable heat treatment of the rails. Either of these processes improves the mechanical properties of the steel (its resilience in particular) with a reduction in grain size, the grain size increasing almost geometrically as the final temperature increases in arithmetical proportion (7).

In recent years, the disadvantages of brittleness have been confirmed by the following observations : horizontal lines under the foot of the rail known as « rolling lines » have been the cause of rails breaking in service; the cause of these lines, which may or may not be visible on the surface, is still disputed, but has been attributed by three authors to blowholes, elongated by rolling, near the edges of the rail section, and due to the metal being insufficiently deoxygenated (8).

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(7) See article by Mr. STUMPER in *Stahl und Eisen*, 7th February 1929, page 185.

(8) See : 1. Messrs. CAMBOURNAC and PATTE'S report at the Madrid Congress, (1930), in the October 1929 *Bulletin of the International Railway Congress Association*, pp. 2020 et seq.

2. *Bulletin of the International Railway Congress Association*, July 1897, article by Professor TETMAYER: « The black spots on ma-

Furthermore many tests on 0.70-m. (2 ft. 3 1/2 in.) lengths of rail, showing rolling lines on the foot, the foot being tested in tension under a 300-kgr. (660 lb.) tup, showed that fracture occurred at the first blow, even from a low drop when the metal is brittle. On the other hand, rails of non-brittle steel, even with rolling lines on the foot, stood a number of blows from the same tup dropping from a height of 5 m. (16 ft. 5 in.)

Figure 1 is a 0.70-m. (2 ft. 3 1/2 in.) length of rail broken with the foot in tension at the first blow, from a 300-kgr. (660 lb.) tup falling 0.50 m. (1 ft. 7 11/16 in.).

Figure 2 shows the underpart of the foot

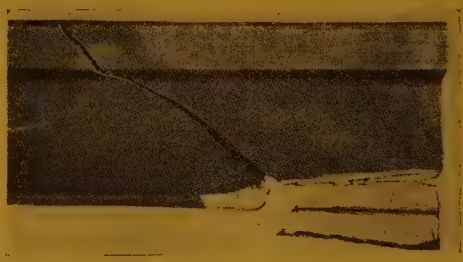

Fig. 1. — Short length of rail broken at the first blow from a 300-kgr. (660 lb.) tup dropping 0.50 m. (1 ft. 7 11/16 in.).

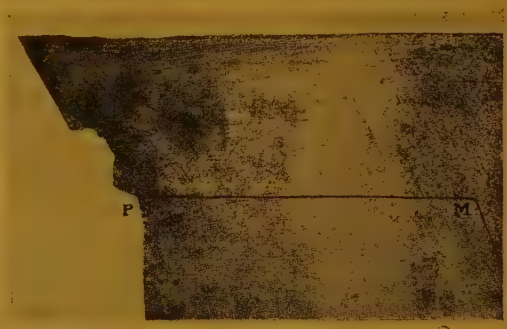

Fig. 2. — Underside of the foot of a rail showing a rolling line.

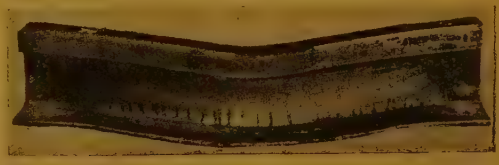

Fig. 3. — Short length of rail, without rolling line, which stood blows of a 300-kgr. (660 lb.) tup falling 1 to 10 m. (3 ft. 3 3/8 in. to 32 ft. 9 3/4 in.).

of a rail with a rolling line having a right angle deviation in it at M : the same sort of fracture would appear to have occurred at P and resulted in the rail breaking right across.

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crographs, along the profile of rails, extending through the web down to the foot, are pores due to blowholes, lined with impurities ».

3. *Revue de l'Association technique de la Sidérurgie*, March 1928, article by Mr. Fétick : « Oxygen is undoubtedly the most dangerous element in steel, and is the cause of the defects encountered in rolling and forging, such as the cracks and lines which are the nightmare of the steel maker. Steel containing oxygen is as a rule markedly heterogeneous, and this impurity, as much as phosphorus, is the cause of the lines in rolled or forged steel (glust in English) which under mechanical action may start internal cracks. The lines in the direction of rolling are weak points, as under further working fissures can start which may adversely affect the rolled or forged part and prevent welding ».

4. *Stahl und Eisen*, 7th February 1929. Influence of the rolling temperature on the properties of rails, by Mr. Stumper : « An examination of the curve shows that the number of rails rejected decreases as the excessively high rolling temperature helps to close up the surface blowholes, themselves really the origin of most surface defects ».

5. R. Kühnel : « Work of the German Commission for testing rails » containing a detailed investigation into longitudinal fissuration of the foot of rails and in particular the description of a means by which invisible fissures are revealed by testing under a press (Second International Day on Rails, Zurich, 1932).

6. See the *Génie Civil*, 2nd July, 1932 : Jean Cournod and Louise Halm, « Oxygen in steel products », page 8, from the eighth paragraph to the section « Cast Iron », and in particular the conclusion dealing with the direct check of the practical absence of included oxygen in steel, based on a cold-working and ageing test. This method is said to have given entirely satisfactory results.

Figure 3 shows a short length of rail free from rolling lines in the foot, which stood blows of a 300-kgr. (660 lb.) tup falling 1, 2, 3 etc. metres (3 ft. 3 3/8 in. — 6 ft. 6 3/4 in. — 9 ft. 10 1/8 in., etc.), the last being 10 m. (32 ft. 9 3/4 in.).

The different results confirm the necessity for checking the brittleness and homogeneity of the steel.

The above quoted article of 1926 drew attention to rail breakages occurring at the fish plate bolt holes, which were also due to the steel being very brittle (fig. 4).

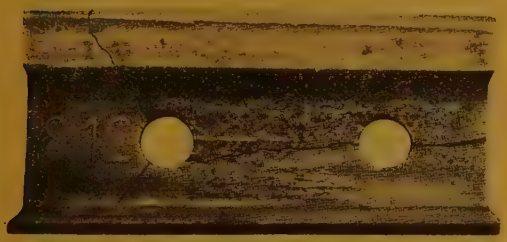

Fig. 4. — Rail with fissures starting from the fishing holes, with wear and deformation at the joint.

The Belgian National Railways have just laid in the Brussels-Liége line. as an experiment, rails the ends of which, after finish rolling, have undergone treatment at the works, by a process invented by Mr. Servais. This process should have the double advantage of preventing star-shaped cracks at the bolt holes and of reducing wear and deformation of the rails at the joints.

The *Paris-Lyons & Mediterranean* Company has used the *New York Central* supported joint « with which the proportion of defects in the fishing area is very low (one defect in this area to thirty outside it). » This figure was given at the London Congress (1925) (9).

The supported joint used with rails treated by Mr. Servais's process should give excellent results.

B. *Segregation.* — The French Railway Companies' specifications now prescribe a macrographical test. As a result there has been a marked improvement in the quality of the rails accepted, extensive segregation no longer being found.

In the 1926 article (see figures 50 and 51 therein), we showed that internal transverse fissures (silvery oval spots) were due to the difference in elongation, when hot, between the segregated core and the relatively sound ductile metal surrounding it, in the head; the longitudinal stresses to which the segregated part is subjected can cause the metal to tear and produce cavities (fig. 51).

We feel that most probably one of Mr. Houbaer's theories, that of the formation of carburised deposits in the rail head, is the true cause of transverse fissures (10).

These carburised deposits resulting from the liquation of the carbon (11) are more prone to set up fissuration the higher their carbon content. For this reason, the carbon content of rail steel should be kept as low as possible.

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(9) See Proceedings of the London Congress (1925) : Question II. — Rail Breakages. Joints. — Sectional discussion, pp. 234/235, March 1926 issue of *Bulletin of the Railway Congress Association.*

(10) See : « Composition chimique des aciers à rails » (Chemical composition of rail steels), by A. Houbaer, *Revue Universelle des Mines,* 15th January 1929, Liége.

(11) See: *Bulletin of the American Railway Engineering Association,* No. 3, 15th March 1929, W. C. Cushing. Rail and Wheel, Part III, page 279.

Chemical analyses of rail steels made by the Pennsylvania System Test Department. In 28 analyses, the segregation of carbon varied from 1.38 % (minimum) to 46.22 % (maximum).

See also *Bulletin of the Railway Congress.* — Mr. Cushing's report to the London Congress (1925), on Question II. — October 1924 issue, pages 677 et seq.

However this may be, « One is led to wonder if the defects only arise when, prior to being laid in the track, the rail contains actual internal fissures which have already begun to work through the sound metal, fissures which start from segregated nodules and are the result of the considerable stresses occurring during manufacture : rolling, cooling, and cold straightening » (12).

This question in connection with brittle steels has caused much thought and ought to be thoroughly explored. Defective rails ought never to be laid in the track.

In this connection, the Sperry detector vehicles should be mentioned as their use, which appears likely to become general, has been attended with much success. Their detector, when run over the track, reveals internal defects by variations in the magnetic field which it sets up round the rail. Its drawback is that it only deals with the head and not the web and foot. Therefore, defects in the fishing are not revealed, neither are fissures in the web, nor rolling lines or other defects in the foot. Owing to the principle on which it is based, the Sperry detector can be used to investigate all defects characterised by discontinuity in the metal. A detector of this type might therefore, in our opinion, be used in the works in order to reveal the same defects due to manufacture and to reject rails containing them.

C. *Piping.* — Piping, which is due to skrinkage of the steel whilst solidifying in the ingot mould, is an unavoidable physical effect. Indeed, solidification starts from the outside of the ingot towards the inside. A cavity in the form of a cup, known as the pipe, forms at the top. When the metal is completely *deoxygenated* before pouring, and the top of the ingot mould is kept hot the longest possible time before solidification, the depth of the piping may amount to :

58.4 % of the height of the ingot when there is no header, poured in a straight mould, i.-e. tronconical with the largest cross section downwards;

26.6 % when the largest section is upwards (inverted mould);

15.3 % in the case of ingots poured in inverted moulds with headers, normal heating;

5.96 % for ingots cast in inverted moulds with specially large headers (13).

When the metal is not completely *deoxygenated,* the bubbling of the metal during cooling hinders the localisation of the piping with the result that it is dispersed throughout the ingot in the form of innumerable micro-pipes invisible to the naked eye, but discernable with a microscope of sufficient power; these small cavities are always accompanied by impurities containing sulphur. Such steel in which the piping is not localised is known as ring steel by metallurgists. As it is very ductile it is easily rolled, drawn and stamped, and is consequently much liked for certain work such as sheets for motor car bodies, tubes, wire, etc... There are serious objection to its use, however, in rolled

(12) Cf. Messrs. Cambournac and Patte's report, page 2027.

(13) See the sketches, figures 62 and 65 of the article « Les ruptures accidentelles des rails » (Accidental Breakages of rails in service), *Revue Générale des Chemins de Fer,* May 1926; See also « La Métallurgie et la construction des chaudières » (Metallurgy and boiler construction), by Mr. Charpy (*Génie Civil,* 26th May 1928, page 508) : « When the metal is not fully deoxygenated before tapping, it releases, during solidification, bubbles of gas which may remain imprisoned in the metal. The cavities thus formed, known as blowholes, compensate the contraction, often partly, sometimes fully. In the latter event, the ingot will be free from piping and no discard is needed ».

material which has to withstand wear and oxidation, such as rails for which purpose a thoroughly deoxygenated steel is required.

To eliminate piping in the case of rails, the tops of the ingots are discarded proportionately to the deoxygenation obtained. The discard in the case of steel works not equipped to bottom-pour ingots with risers should correspond with an incomplete though acceptable deoxygenation, this discard being say 30 % as on the Belgian National Railways. For information, some French and foreign companies require the steel works to use ferro-silicon to ensure perfect deoxygenation, this alloy in order that its use may be successful and free from any disadvantages, being introduced *in liquid form* into the ladle.

D. *Wear.* — In recent years abnormal wear or crushing of the rail head has been experienced, sometimes after very short service. These prematurely ruined rails, moreover, had replaced rails which had stood up perfectly well for many years. This serious defect was attributed first of all to a heavier tonnage over the lines than in previous years, and to the steel being too soft. It was then found that rails of hard steel showed the same defect, and that grooved steel rails of 81-kgr. (51.4 Engl. tons per sq. inch) steel in city tramways had worn prematurely in the groove and

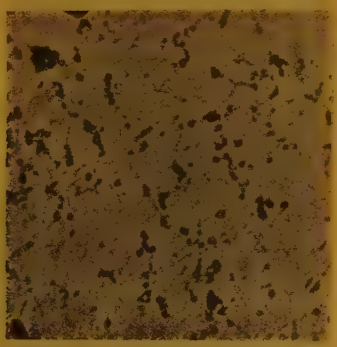

Fig. 5. — Before etching. (Magnification = 100).

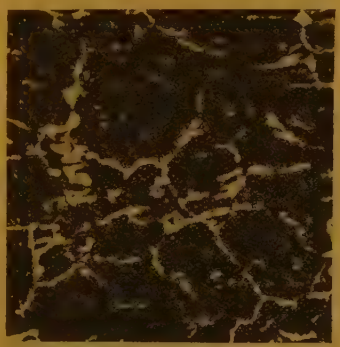

Fig. 6. — After etching. (Magnification = 100).

Fig. 5 and 6. — Rail R_4 [Carbon = 0.53 %; Strength = 82 kgr./mm² (52.0 Engl. tons per sq. inch); Elongation 11.5 %].

been crushed down on the running surface.

Figures 5 and 6 are micrographs from three of these rails, before and after etching. Those taken after etching show that the metal was highly carburized; the structure prior to etching revealed the presence of many micro-pipes, cavities, blowholes, and impurities, through the steel being badly manufactured. These defects may also result in the rails breaking through fissures extending from one impurity to another (14).

The micrographs (figs. 11 and 12), before and after etching, relate to a rail from heavily worn track, which had given a very long service.

(14) See « Contribution à l'étude des impuretés dans les rails de chemins de fer » (Contribution to the investigation into impurities in railway rails). Marqueyrol and Merklen (*Génie Civil*, 25th May 1929).

The micrographs must be carefully studied before and after etching, as the etched, faces do not reveal the, blowholes and microcavities due to defective manufacture, visible before etching.

According to Professor H. M. Howe, cross crystallisation with white segregation lines in the dendrites, sometimes observed in prematurely crushed rail heads, is also due to the steel having been deoxygenated insufficiently (15).

To put it shortly, premature wear or

Fig. 7. — Before etching. (Magnification = 100).

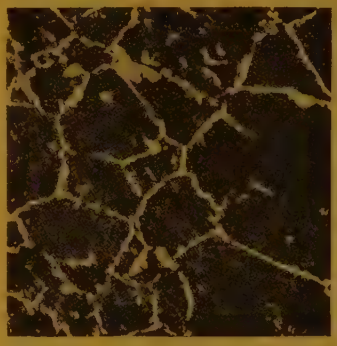

Fig. 8. — After etching. (Magnification = 100).

Figs. 7 and 8. — Rail R_2 [Carbon = 0.53 %; Strength = 81.3 kgr./mm² (51.6 Engl. tons per sq. inch); Elongation = 14 %].

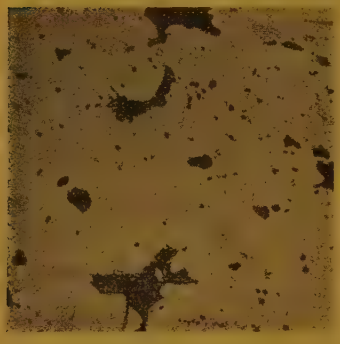

Fig. 9. — Before etching. (Magnification = 100).

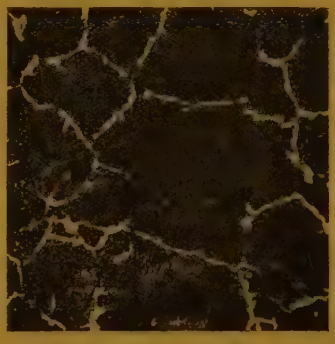

Fig. 10. — After etching. (Magnification = 100).

Figs. 9 and 10. — Rail R_3 [Carbon = 0.53 %; Strength = 77.2 kgr./mm² (49.0 Engl. tons per sq. inch); Elongation = 14 %].

crushing of the rolling surface of the rails is not always due to the tonnage carried nor to the rails not being hard enough, seeing such defects occurred

(15) See *Metallography of steel and cast iron*, by H. M. Howe, §§ 772 to 775. It is said in § 775 that « the conditions leading to the dendrites being closely bound together, to the dendritic segregation not being accentuated, and to a reduction in the central segregation under the piping include : low pouring temperature, use of heavy cold moulds, ingots of small section, and above all perfect deoxygenation of the metal ».

with tramway rails made of very hard steel; the defective manufacture of the metal is therefore the cause.

Figures 5 to 12 show whether micro-cavities and blow holes are present or not. Figure 13 shows two inclusions of manganese sulphide. Figure 14 shows the Widmannstätten structure, charac-

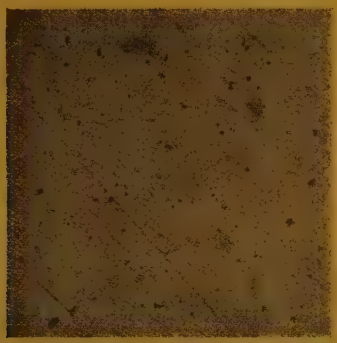

Fig. 11. — Before etching. (Magnification = 100).

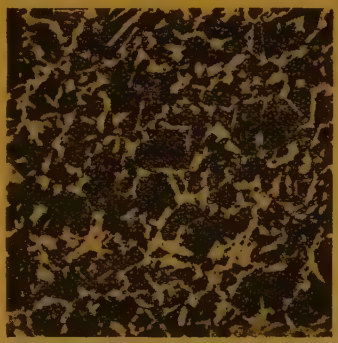

Fig. 12. — After etching. (Magnification = 100).

Figs. 11 and 12. — Rail R_4 [Carbon = 0.42 %; Strength = 71.5 kgr./mm² (45 Engl. tons per sq. inch); Elongation = 20 %].

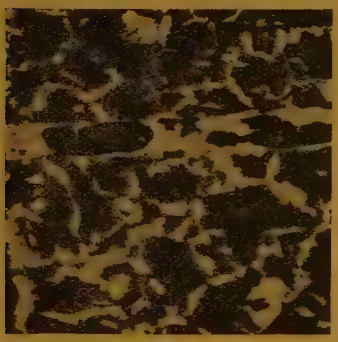

Fig. 13. — Micrograph showing two manganese sulphide inclusions.

Fig. 14. — Micrograph showing the Widmannstätten structure, characteristic of overheating.

(Magnification = 130).

teristic of too high temperature at the end of rolling, with excessively coarse grain. Micrographs 15 and 16, on the other hand, are from steel of good quality and not brittle [16].

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[16] See *L'Industrie des voies ferrées et des transports automobiles* (October, November and December, 1930). M. Legrand: « Contribution à l'étude de l'usure de l'acier sans lubrifiant » (Contribution to the study of the wear of steel when not lubricated). — « Application aux rails et bandages » (Application to rails and tyres).

According to M. Legrand's third conclusion: « The wear by abrasion, all other things being equal, for loads exceeding the coldworking limit, is proportionately less as the final strength is greater. Our tests confirm M. Frémont's opinion ».

E. *Heat treatment of rails.* — The Neuves-Maisons Works had developed an effective method for heat treating their rails, prior to the London Congress of 1925.

This Company's process, based on experiments carried out by Professor J. E. Stead in 1903, was described in the remarkable article by Messrs. Thibaudier and Viteaux, published in 1926 by the *Revue de Métallurgie*. The authors called attention, on page 18, to the advantage of the treatment, especially when applied to milder steel than that previously used, as by its use it becomes commercially possible to manufacture rails free from brittleness, of high elastic limit, and which will give good resistance to wear.

Mr. Viteaux added ([17]) that « the greatest importance must be attached to the purety of the steel, and the heat treatment will be proportionately more effective as it is applied to a more carefully prepared metal ».

We should add that when there is a relatively low carbon content, such as C = 0.42 % maximum, the carburized

Fig. 15. — Micrograph before etching the polished surface (Magnification = 100).

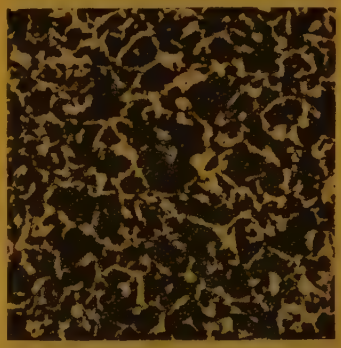

Fig. 16. — Micrograph after etching the polished surface (Magnification = 100).

Figs. 15 and 16. — Rail of good quality.

nodules resulting from the inevitable liquation of the carbon dealt with in paragraph B — *Segregation* — are less liable to set up fissuration and other effects of hardening.

Since the above mentioned pamphlet was published, the process has been applied in many cases, both at Neuves-Maisons and elsewhere, and these have confirmed the above remarks of Messrs. Thibaudier and Viteaux : experience has shown that the treatment increases the resistance to hammering, besides giving excellent wearing qualities in the case of the heads of rails with marks due to slipping.

Important though these results are, they do not completely solve the problem of brittleness. The treatment is only partial, and only affects the rail head, the bevelled- off ends of which frequently crack through the fishing bolt holes and sometimes even break. Examination of the quality of the metal in the web and foot is therefore still necessary and should be carried out by metallographical and brittleness tests.

([17]) *a)* See Henri Viteaux : « Les traitements thermiques des rails » (Methods of heat treating rails). *Liége, International Congress, June 1930*, Metallurgical Section, p. 416.

b) Some companies, for this reason, specify that the treatment is to be given to rails from the bottom of each ingot only, the rail from the top being excluded and only being passed for ordinary use when it complies, as regards quality, with their specifications.

In connection with brittleness, Messrs. Cambournac and Patte mentioned in their report to the 1930 (Madrid) Congress (pages 2049 and 2050), that the French railways were led to specify a test method which would demonstrate the efficacy of the heat treatment. This method was based on the drop test, a weight of 300 kgr. (660 lb) falling on short pieces of rail, 0.70 m. (2 ft. 3 1/2 in.) long, notched by means of a fine saw cut on the Merklen method, and placed head downwards on supports placed 0.50 m. (1 ft. 7 11/16 in.) apart.

This test consists of 10 blows from a height of 0.50 m. (1 ft. 7 11/16 in.), the rail being turned over after each blow; 10 blows from 1 metre (3 ft. 3 3/8 in.) under the same conditions; then with the rail head in tension, one blow from 2 m. (6 ft. 6 3/4 in.), one blow from 3 m. (9 ft. 10 1/8 in.), and so on to fracture. We think a test based on this procedure can be introduced into the specifications in the near future.

Such tests have shown the efficacy of the method, devised moreover, to reproduce as far as possible transverse fissures due to skidding. The very fine saws, however, wear very quickly

Fig. 17. — Sorbite. (Magnification = 130).

Fig. 18. — Martensite. (Magnification = 130).

Figs. 17 and 18. — Results of heat treatment with annealing (fig. 17), and without annealing (fig. 18), applied to a rail of good quality.

and as they are difficult to make, there is usually great delay in obtaining supplies. To overcome these difficulties the Italian State Railways use a saw 1 mm. (0.039 inch) thick. This saw is much easier to use and the results appear to be similar to those obtained with finer saws.

At all events, and independently of the drop tests with a 300-kgr. (660 lb.) tup, resilience tests ought to be made on the metal in the web and foot. Moreover, the micrographs taken from the treated portion of the short length of rail broken under the drop test should show a sorbitic and not a martensitic structure (figs. 17 and 18). We do not think, as some metallurgists, in Germany in particular, have suggested, that rails should be manufactured with the structure either partly or wholly martensitic to prevent excessive wear on small-radius

curves. We consider it better, in the interests of safety, to require the whole of the treated zone to be suitably tempered so as to obtain « the sorbitic appearance typical of good resilience, which justifies the use of sorbitic steels for metal parts of the best quality » (18).

Finally the grooved rails known as « compound », manufactured by the ILVA Metallurgical Company (Italy) for the Milan tramways, should be mentioned. The running surface and the guard lip have a 0.6 % carbon and 1.349 % manganese content (R = 114.3 kgr. = 72.5 Engl. tons); in the rest of the section, the carbon content is 0.17 and the manganese 0.596 % (R = 44.6 kgr. = 28.3 Engl. tons). The rolling finished at a low temperature, with normal cooling, produces a sorbitic structure in the extra-hard portion.

The manufacture of rails of this kind gives rise to difficulties and problems which lead us to prefer heat treatment, as more easy to carry out.

Conclusions.

For reasons of safety and good maintenance, unsound rails from badly manufactured, heterogeneous, or brittle steel must be kept out of the track.

The specifications, therefore, should provide first of all for the selection to be made at the works, and subsequently should provide means for investigating the causes of breakages or defects occurring in service.

One of the tests now imposed is the tensile test (19), which is purely statical and does not take into account the violent blows in all directions the track receives from the rolling stock (20). The results obtained therefrom even if they indicate good ductility of the metal, cannot be taken as conclusive when considered from the essential point of view considered above.

We agree on this point with many scientists and experimenters as the following quotations show :

1. « To sum up, the usual tensile test gives no information at all on the strength of the parts in service, and is far from having the value attributed to it. The inspection tests it is essential should be laid down in the specifications are those relating to *corrosion* and *brittleness.* » (CH. FRÉMONT : Study on the tensile testing of metals, § 657, page 167, Paris, 1927.)

2. « The classic tensile and bending tests are generally considered at the present time as insufficient and as failing to reveal certain undesirable features, the most frequent being the progressive fissuration or fracture, as the result of impact, of plates which, when tested in tension, had failed only after the usual elongation. » [G. CHARPY : « La métallurgie et la construction des chaudières » (Metallurgy and boiler construction), *Génie Civil*, 26th May 1928, page 508.]

3. « Impact tests on notched bars in many instances enable us to form an idea of the strength of the parts in service, whereas the tensile and the old methods of making bending and crushing tests by impact fail to do so. These tests ought, therefore, to be discontinued... When the considerable cost involved in preparing test pieces and making mechanical tests is taken into account, macrography and micrography give in certain instances more valuable information at less

(18) See GRARD and COURNOT, « Métaux et Alliages » (Metals and Alloys), volume II, page 93.

(19) The tests imposed in the present French railway specifications are the following :

Macrographic tests; drop test on short notched lengths of rails; tensile test; hardness test (for information).

(20) See *Mémoires de la Société des Ingénieurs Civils de France* (Proceedings of the Institution of Civil Engineers, France), November and December, 1933. M. BACQUEYRISSE : « Le rail et la roue » (Rail and Wheel). Conclusions, pp. 1227 and 1228.

cost. » (N. P. Nicolau, Major of artillery : « Recent progress in inspecting metal products ». *Bulletin de la Société d'Encouragement pour l'Industrie nationale*, February, 1930, pp. 130 and 133.)

4. Lastly, Mr. Ch. de Fréminville, President of the French Institution of Civil Engineers, in his presidential address (reviewed in the *Génie Civil* of the 27th January 1934, page 88), pointed out that when selecting metals to be subjected to unusual stresses, the problem of brittleness raised by Considère resulted in the introduction of the drop test, and in particular with the Frémont tup, which had been of the greatest value to him in the manufacture of automobiles.

The above quotations are corroborated by the following observation : we know of no case in which the tensile test, repeated with the most modern machines, has enabled us to ascertain the cause of rails breaking or developing defects in service. The metallographic or brittleness tests have been the only ones by which these defects have been revealed (21).

Our proposal to modify the present specifications by abandoning the useless rigour upon the tensile tests and to complete them by the undermentioned requirements is based, therefore, on a whole series of undisputed facts.

The tests to be made before material is passed would therefore be :

1. Drop test to be made with a 300-kgr. (660 lb.) tup on a short length of rail either notched or not;

2. Resilience test;

3. Metallographical tests;

4. Hardness tests.

5. Tensile tests (in special cases and for information only), and

6. Chemical analysis, if deemed desirable.

I. *Drop tests.* — Tests with the 300-kgr. (660 lb.) tup should be carried out to ascertain the quality of the heat treatment, and the strength under dynamic stresses of rails with rolling lines :

a) heat-treated rails : by drop tests on 0.70-m. (2 ft. 3 1/2 in.) bars notched across the rail head half way along the length, 1.5 mm. (0.059 inch) deep, with a 1-mm. (0.039 inch) thick saw (if finer saws not available). The test bars to stand, before fracture, ten blows from a height of 0.50 m. (1 ft. 7 11/16 in.) with the rail head alternatively under tension and compression. The drop test then to be continued with the head of the rail underneath, until fracture occur by increasing the height of drop to 1 m. (3 ft. 3 3/8 in.), 2 m. (6 ft. 6 3/4 in.), 3 m. (9 ft. 10 1/8 in.), etc... The fracture through the heat-treated zone to show, under micrographical examination, a sorbitic structure as indicated above;

b) rails with rolling lines : 0.70-m. (2 ft. 3 1/2 in.) lengths of rail showing such lines under the foot to be tested with the foot in tension and not notched, and to stand, before fracture, three blows from a height of 5 m. (16 ft. 5 in.).

II. *Resilience tests.* — Resilience tests to be made on Mesnager test pieces with a 2 mm. (0.079 inch) deep notch cut in the direction of rolling from the head, web, and foot (from the web and foot only in the case of heat-treated rails) at various points in the bars from the same ingot. The results obtained to vary but

(21) See also J. Willem and J. Servais : « The new testing conditions in the Belgian State Railway's specification for rails ». *Bulletin of the Railway Congress Association, november 1926*, page 976 : « It should be noted that only macrographical and micrographical tests confirmed by resilience tests are able to reveal the cause of premature scrapping and it is along these lines that investigations should be pursued in the future when inspecting rails ».

See the same article, pages 977 and 978, for the very good macrographs taken before etching from defective rail steels.

slightly, thereby proving satisfactory homogeneity with a minimum of 3 kgrm./cm² (140 ft. lb., per sq. inch).

III. *Metallographical tests.* — *a*) The macrographical tests to be carried out according to the requirements of the existing specifications;

b) Micrographs to be taken from the remains of the resilience test pieces to check the proper crystalline structure of the steel, and to make it possible to reject over-heated rails, rails containing blowholes or piping, featuring badly worked up steel.

To prevent disagreement as to the interpretation of the micrographs at the works, the test pieces examined in the works should be sent to the headquarters laboratory of the railways, where the final investigation can be made either at the Le Chatelier bench or with similar equipment, if available, or by means of microscopes capable of 200 magnifications, fitted with cameras for reproducing the texture of the metal on a sensitive plate. Instruments of this kind are now used in France and other countries.

IV. *Hardness tests.* — Brinell hardness tests, on straight sections from the head of the heat-treated rails, to be specified in order to ascertain the hardening obtained and its effective penetration.

V. *Tensile tests.* — The classic tensile tests might be retained optionally for documentary purpose, in order to ascertain the elastic limit and the quality of the steel. This latter quality, however, can be ascertained at less cost by making a series of Brinell tests on pieces cut from the ends of the rails from each ingot; these Brinell figures would provide accurate information as to the homogeneity of the metal and so assist the inspectors in selecting the position from which the resilience notched test pieces should be cut.

In addition, a chemical analysis would be made when required. This would enable the carbon content to be checked; in the case of rails intended for treatment, the carbon content must not exceed 0.42 %. The Mn, Si, S and P contents being thus known, some of the abnormal features revealed by the other tests would be accounted for.

A detector on the lines of the Sperry device would also be desirable for use at the works themselves, for investigating defects or internal fissures set up during manufacture and showing which, if any, rails should be rejected.

In support of this classification of the tests in their order of importance we should note :

1. The example from the diagram, figure 29, of Messrs. Cambournac and Patte's report quoted above (paragraph A : Brittleness; Homogeneity);

2. Very low resilience value, the excessive brittleness of the steel being confirmed by observation on the sections of the Mesnager test pieces of the acicular structure, characteristic of overheated metal;

3. Finally, rails broken in service with rolling lines in the foot, short lengths (0.70 m. = 2 ft. 3 1/2 in.) of which, drop tested with a 300-kgr. (660 lb) tup having revealed their extreme brittleness.

Obviously, had such observations been recorded during manufacture, even for documentary purposes, the purchaser would have accepted much responsibility had he accepted rails so likely to break in service.

Then too, as Major Nicolau writes, the drop test on notched bars is not a new test; such tests are the standard practice of the Italian State Railways and, in conjunction with the Mesnager test piece, which has proved entirely suitable for rail steels. Messrs. P. Forcella, A. Steccanella and G. Meucci, of the Italian State Railways, have expressed the same opinion in some valuable articles they

published in the *Rivista Tecnica delle Ferrovie Italiance*, in 1925.

In France, as elsewhere, therefore, this type of test piece has been used already in thousands of resilience tests on rails, and the results confirm that the minimum of 3 kgr./cm² (140 ft./lb. per sq. inch) suggested above can be prescribed without exaggeration.

The reasons given below, however, lead us to think that ultimately, instead of the Mesnager notch, which requires very accurate machining, the saw cut suggested by Frémont (22) will have to be resorted to.

Drop tests on short lengths of heat-treated rails notched with a fine saw cut, have shown that the extreme thinness of the saw is not so important as we thought. Microscopical examination (50 diameters magnification) of the bottom of the notch so obtained revealed extremely fine fissures (about 0.6 mm. = 0.023 inch long) which did not affect the test results as the metal in which they were recorded was not brittle. These observations show that too great importance must not be attached to the form and the machining of the notches in resilience test pieces, because any imperfection in them does not falsify the test results.

It should be remembered that clause 4, Question II : « Resistance of rails to breaking and to wear » (23), of the 1930 Madrid Congress, agrees with our proposal subject to the proviso that, in our opinion, the resilience tests « which enable us to ascertain if the steel is brittle » should be made for elimination purposes, as we have already said and not merely to serve as a basis on which to allot premiums for good quality ».

Nothing has been said so far about « the endurance tests of rails i. e. their resistance to repeated stresses », nor on the investigations and measurements of the stresses which develop in rails under passing wheels (Paragraphs *c* and *d*) of footnote 23.

In our opinion, the endurance test consisting of a hammer of small mass, falling from a small height, in no way resembles the violent blows in all directions, exerted by the rolling stock, as mentioned at the beginning of our conclusions. Professor Portevin's opinion on this matter is a follows :

Mr. Portevin pointed out « that the results of the repeated shock test depend especially on the elastic limit of the material and have no relation to this important factor, resilience. Then too, the resilience test is included in the specifications, the conditions of the test are clearly defined, and the test is carried out in a uniform manner. The fatigue test, on the contrary, is not a standard.

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(22) See Ch. Frémont, 38th pamphlet : *La fatigue des métaux et les nouvelles méthodes d'essais* (Fatigue of metals and new test methods), page 16. Abstracted from the *Génie Civil*, 22nd and 29th October, 19th and 26th November, 1910. « In a paper presented to the 1900 Congress, we showed that this method of notching allowed for wide tolerances, as regards length and depth, without any practical disadvantage. During the last ten years, workshop practice based on millions of test pieces has proved how well founded our remarks were ».

(23) It is recommended that the following should be developed :

a) macrographical tests for determining the homogeneity of the cross section. In their present form, these tests can be used for elimination purposes, i.e. for the elimination of rails which are not uniform throughout;

b) elasticity tests for determining the degree of brittleness of the metal. These tests, in their present form, do not enable brittle rails to be rejected, but they are already sufficient to serve as a basis for the granting of quality premiums. It would be an advantage if research could be continued in order to perfect a fragility test applicable to the whole cross section of the rail;

c) laboratory research and tests relative to the endurance of rails, i.e. to their resistance to repeated stresses;

d) research and experiments relative to the stresses which develop in rails under passing wheels. (*Bulletin of the Railway Congress*, December 1930 number, p. 2237.)

The methods vary from laboratory to laboratory giving results which cannot be compared with one another, and on which unjustifiable generalisations or comparisons (24) can be come to ».

On the other hand, Messrs. GRARD and COURNOT have expressed the following opinion on this test :

« The elastic limit plays therefore the predominant part in the resistance to stress. We ask that the resilience be above a certain minimum of 8 to 10 kgr./cm² (373 to 466 ft./lb. per sq. inch). This minimum resilience being complied with, the highest possible elastic limit is to be sought for, to stand up to repeated stresses » (25).

As regards the stresses which are set up in the rails by passing wheels, we understand research work is in hand which, it would appear, will ascertain the magnitude of the blows on the rails, the value of which blows was discussed at the 1925 London Railway Congress. It was stated, in fact, that the dynamic forces set up by the moving masses of the locomotive mechanism or badly adjusted springs (which Mr. Marié dealt with in great detail in his pamphlets on the oscillations of rolling stock), produced a serious increase in the axle load and frequently resulted in broken rails (26).

Subsequently, Mr. Bacqueyrisse has shown the magnitude on the blows transmitted by the wheels to the present non rigid track, in a paper « Le rail et la roue » (Wheel and Rail) published in full in the November-December *Bulletin de la Société des Ingénieurs Civils de France* (27).

In this connection, we would remind our readers of the experiments carried about 1894, over several weeks, with the Heilmann electric locomotive between Beuzeville and Havre. It was found at that time, by using Marey-Coüard explorers (28), that the forces exerted in all directions on the rail by the electric locomotive were much lower than those set up by steam locomotives.

Moreover, electric locomotives of the Heilmann type are again causing interest in railway circles, judging from the recent test on the *Paris-Lyons & Mediterranean,* of a diesel-electric locomotive which is very much simpler than the Heilmann locomotive as it has no boiler. Like its predecessor, however, it is entirely self-contained, which gives it much superiority over electric traction taking current from the feeder lines, by rendering it independent of power stations and transmission lines. This engine has the same advantages as its predecessor over the steam locomotive as regards the forces set up in the track.

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(24) See *International Congress,* Liége 1930 (Metallurgical section). Report by Messrs PORTEVIN, CRETET and JOLIVET : « Propriétés mécaniques des barres forgées » (Mechanical properties of forged bars). Reply by M. PORTEVIN to Mr. HOUDREMENT'S suggestion to replace the resilience test by the repeated shock test.

(25) See GRARD and COURNOT, « Métaux et Alliages » (Metals and alloys). Vol. 1, pages 115 and 156.

(26) See reports to the London Congress 1925 : Question II — Rail breakages. Joints — Sectional discussion, *Bulletin of the International Railway Congress Association,* March 1926, p. 233.

(27) A rigid track carrying vehicles with elastic wheels and cylindrical tyres would, in Mr. Bacqueyrisse's opinion, mean substantial progress in speed, comfort, and safety; we think, in addition, it would reduce the number of broken rails in service and make the consequences less serious.

(28) The Marey-Coüard instruments were described by Mr. Coüard in the October 1887 number of the *Revue Générale des chemins de fer.*

[621. 392 & 624]

Strengthening railway bridges by welding,

by Dipl.-Ing. Otto BONDY, V.D.I., M.I.A.B.Struct.E.

(The Railway Engineer.)

Owing mainly to greater axle loads, higher train speeds, or the combined effect of these developments, it is frequently necessary either to strengthen an existing bridge or to replace it by a new one. This problem is specially, but by no means exclusively, liable to arise where electrification schemes are concerned. In every case it must be decided whether it is more economical to build a new bridge or strengthen the existing structure. Much depends on the method of reinforcement which it is proposed to use. For many years past, riveted bridges have been strengthened by riveting, but the advent of electric welding and the wide and satisfactory experience acquired by its use have revolutionised the repair and strengthening of steel structures. Work of this nature has been executed on an increasing scale in almost every industrial country during recent years, and the more fully advantage is taken of experience thus acquired, the better and more economical is welding compared with riveting.

Very successful results have already been thus obtained in England, including the important work carried out by the London and North Eastern Railway in the neighbourhood of York. The strengthening of the lattice bridge at Denaby is one of the latest (1933) and finest examples of the capabilities of electric welding. In Australia, railway and road bridges have been strengthened by welding for many years past, and by the end of 1931 there were already 74 railway bridges thus reinforced in that country.

On the Continent, and particularly in Germany, developments in this field commenced later, but they have extended rapidly during recent years and there are now a number of examples which deserve consideration, not merely on account of their magnitude but particularly in respect of their novel structural features. The examples of strengthened German railway bridges illustrated in this article have been selected from this point of view.

Advantages of welding.

The advantages of welding, as a means of strengthening railway bridges may be summarised as follow :

1. The welding can be done without any interruption of traffic, the rivets remaining untouched. The safe carrying capacity of the bridge is at no time reduced but, on the contrary, increases as the work of reinforcement proceeds.

2. Quite light scaffolding suffices, the welding generator set usually remaining below.

3. The designer has complete freedom in the arrangement of the reinforcement, and it is possible fully to comply with his requirements in the enlargement of cross section and increase in the moments of inertia and resistance of the various members. Typical examples of this are illustrated in figures 6 and 7.

4. The life of the structure can be prolonged considerably by reducing the load on the existing riveted connections.

5. While strengthening the bridge by welding, its liability to rusting, and the cost of painting the structure, can be reduced by

close-welding the joints and by converting open to closed sections. By these means, open interstices can be practically eliminated and the total surface exposed to the atmosphere can be much reduced.

6. The cost of strenghthening a bridge by welding is generally only a fraction of the cost of a new bridge, and the strengthened structure is often technically superior to the original riveted construction.

While so many advantages can be claimed and upheld so far as concerns the practical application of welding in the strengthening of bridges, it must be admitted that the position on the theoretical side is less satisfactory. Most of the theoretical considerations involved in the design and construction of new welded structures have been fully elucidated during recent years; but the theoretical treatment of combined riveted and welded joints is still far from complete. Research directed towards the solution of a number of problems has been actively in progress in the laboratories of various German universities and testing institutions for come years past and, more recently, valuable investigations have been conducted by Prof. Paton at Kiev (Ukraine). The principal results of the German investigations are given later, but there is no doubt that practice has far outstripped theory and research in the strengthening of riveted bridges by welding. As a consequence, the responsibility resting upon the designer is exceptionally heavy; he must be guided primarily by practical experience in the absence of any completely satisfactory theoretical basis of design.

In a certain case, for example, it was found that the « strengthening » of a diagonal in a lattice bridge actually resulted in weakening the structure. The member in question consisted of two channel irons, each 25 cm. (9 7/8 in.) deep, and it was attempted to strengthen them by welding an 80 × 50 mm. (3 5/32 in. × 1 31/32 in.) flat to the web of each. The penetration of the welds reduced the original section, however, to such an extent that a typical fatigue fracture occurred at the transition to the gusset plate. According to the German rules DIN 1073, a factor of safety of 1.5 against fatigue fracture is provided in riveted structures of mild steel St 37 (tensile strength 23.5 tons per sq. in.), but although the welding was in accordance with the rules DIN 4100, the factor of safety was evidently destroyed. Fortunately, such cases are exceptional and the general trend of experience in the strengthening of many large railway bridges by welding is entirely encouraging.

Extent of strengthening.

Welding may be applied either to the reconditioning of bridges, in the sense of restoring strength lost by rusting or by other chemical or mechanical causes, or it may be applied to the provision of additional strength over and above the original strength of the riveted structure. Damage by corrosion is often particularly severe in the neighbourhood of chemical works, and on the windward side many members may be found to be heavily attacked under apparently sound paint. Another cause of similar trouble is the saline water dripping from refrigerator cars, which often attacks the upper flanges of deck beams. Damage thus occasioned has been remedied in America by welding.

The loosening of rivets in the girder connections, by the repeated stresses to which they are subjected in service, is one of the mechanical factors which may ultimately necessitate reconditioning of the structure. One of the first cases of this kind to be dealt with by welding was in a railway bridge at Leipzig in 1929. Referring to figure 1, the rivets of the connecting angles between the cross girder *a* and longitudinal girders *b* had worked loose. A rigid connection was restored at very small ex-

pense by welding-in bracket plates *c* as shown; a solution which had the further advantage of reducing the load on the rivets. Figure 2 shows a part of this bridge as seen from below, the welded brackets being marked by circles. Four

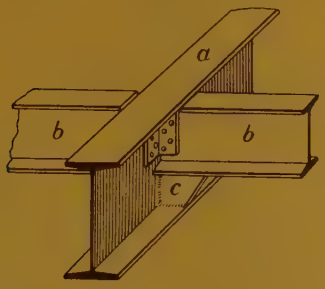


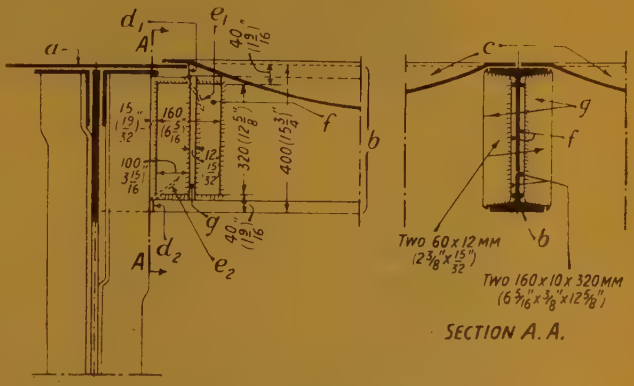
Fig. 1. — Loose riveted connection secured by welded bracket plate.

bridges in the Halle division of the German State Railways were repaired in this way without interruption of traffic.

Combined reconditioning and strengthening.

It is not always easy to differentiate between reconditioning and strengthening operations and, indeed, wherever practicable the two should be judiciously combined. An example of this is to be found in another railway bridge near Leipzig. The drawings, figure 3, show the connection of the I 40 cross girder (standard section 40 cm. = 15 3/4 in. deep) to the main girder of an arched lattice bridge. The cross girder had been cut away at the flanges in order to allow the web to be connected by riveted vertical angles in the usual way. Such notching is, of course, always dangerous from the standpoint of fatigue stresses, and it is a recognised principle of modern construction that sudden changes of section should be avoided. Il the present case, cracks had developed in the web, and repairs were effected by welding on 10-mm. (approx. 3/8 inch.)

Fig. 2. — Four railway bridges in the Leipzig district were strengthened by this method; see also fig. 1. (Hummel & Merken, Leipzig.)



a) = Upper chord of main girder;
b) = Cross girder (rolled steel joint);
c) = Flor plates;
d_1, d_2 = Cut flanges of cross girder;
e_1, e_2 = Cracks in web of cross girder;
f = Reinforcing welded on web of cross girder;
g) = Stiffening plates.

Fig. 3. — Cross girder connection in a long-span arched lattice railway bridge, showing plates welded-on over web cracks in the cross girder.

plates as shown, perpendicular stiffening plates 12 mm. (about 15/32 in.) in thickness being then welded on to each

Fig. 4. — Underside of arched lattice bridge at Wahren station near Leipzig, showing connections repaired as in fig. 3. (Hummel & Merkel, Leipzig.)

side of the reinforcing plates joining the upper and lower flanges of the girder, thus providing tranverse stiffening of the connection. The connection as thus repaired and strengthened may be expected to last longer than the original riveted construction. The accompanying photograph, figure 4, shows a number of the finished connections. The whole of the work was accomplished from hanging scaffolding without interruption of traffic.

In some cases where structures have been strengthened by welding, a certain pre-stressing of parts has been obtained either by the application of heat or by means of hydraulic presses. It seems probable that there will be important developments in this direction, and it may even be possible to utilise constructionally the shrinkage stresses set up by welding. A treatment of the special case of the two-pin frame was published some years ago (1), and it appears that the results of recent experimental investigations can be usefully applied to combined riveted and welded connections. Thus, riveted bar connections strengthened by welding have been subjected to repeated loading superimposed on a basic load, and from the results of these tests, conducted at the Berlin-Dahlem Testing Laboratory (2), it appears that only two-thirds of the live load has to be assigned to

(1) Bondy, *VDI-Zeitschrift*, November 15, 1930.

(2) Kommerell and Bierett, *Der Stahlbau*, May 25 and June 8, 1934.

the welds. The stresses permissible in welds should be utilised as fully as possible, in order to reduce the length of the welded seams and keep their commencement as far as possible from the first row of rivets. In all cases, the geometrical form of the joint is of decisive influence on the fatigue strength, and the mechanical properties of the weld metal — its elongation, tensile strength and notch impact value — are less important than the choice of the correct form.

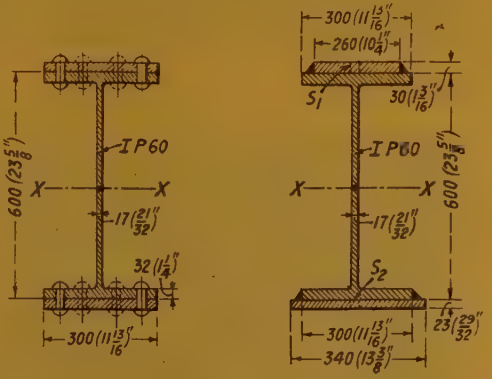
A series of investigations recently concluded at the Darmstadt Technische Hochschule has also given results of practical importance, from which it appears that the strength of a combined riveted and welded connection may be calculated by taking the rivet stress to be two-thirds of the maximum permissible value, and the weld stress to be the full value permitted by the rules. In the specimens used for these tests, the weld always broke before the riveted connection, owing to the smaller elongation of the weld on breaking. Reference is also made in the report on these investigations (3) to the importance of avoiding, by constructional measures, any concentration or intensification of stress which would increase the liability to fatigue fracture. This requirement was emphasised in *The Railway Engineer* of September, 1934, page 277, in relation to the construction of railway bridges by welding, and it is also taken into account by the August, 1934, issue of the German rules for welded structures.

It is, however, easier to say that local concentration of stress must be avoided than it is to ensure the fulfilment of this condition in practice, for it is only recently that the phenomena of repeated loading and fatigue fracture have been thoroughly investigated. On the other hand, the information available is increasing rapidly and, provided that it is studied carefully by the designer responsible for the arrangement and calculation of welded reinforcements, there should be no difficulty in avoiding trouble from fatigue fractures in future.

(3) Kayser and Herzog, *Der Stahlbau*, July 20, 1934.

Welding versus riveting.

There can be no doubt that welding offers decisive economic advantages compared with other methods of strengthening railway bridges, and its applications in this field will continually extend. As a simple example, suppose that an increase in live load necessitates the strengthening of a broad-flange bridge girder IP 60 (60 cm. = 23 5/8 in. deep with 30 cm. = 11 13/16-in. flanges) by the attachment of plates to the flanges. The alternatives of riveting and welding



a) By riveting. *b*) By welding. S_1, S_2 = slot welds.

Fig. 5. — Comparing the strengthening of a broad-flange girder by riveting and welding.

are compared in figure 5, which shows at once that welding provides a « watertight » girder with all joints sealed by welds. Further, welding eliminates the marking out and drilling of rivet holes and avoids the weakening effect of the latter. Both sides of the flanges must be cleaned, free from paint, before riveting can be commenced, but only the out-

side of the flanges needs preparation for welding, and this is an important consideration since there are always other connections rendering the inside of the flanges more or less inaccessible. All four welds can be made conveniently, no overhead welding being required, a smaller weight of steel is needed, and there is a saving on labour costs.

Examples of reinforcement.

This type of section is used not only for main girders of railway bridges but also in lattice frames where quite different forms of strengthening may be desirable in the interests of buckling strength. Various methods of reinforcement applicable to bracings of lattice bridges are illustrated in figure 6, and nearly all of these have already been used satisfactorily in practice. In case (*f*), figure 6, the two 140 × 15 mm. (5 1/2 in. × 19/32 in.) flats are connected by a welded-in web of 10-mm. (3/8 in.) plate, thus converting the slack diagonals of the lattice girder (30-m. = 98 ft. 5 1/8 in. span) to stiff struts offering considerable resistance to buckling. Typical examples of the strengthening of chords for lattice bridges are illustrated in figure 7.

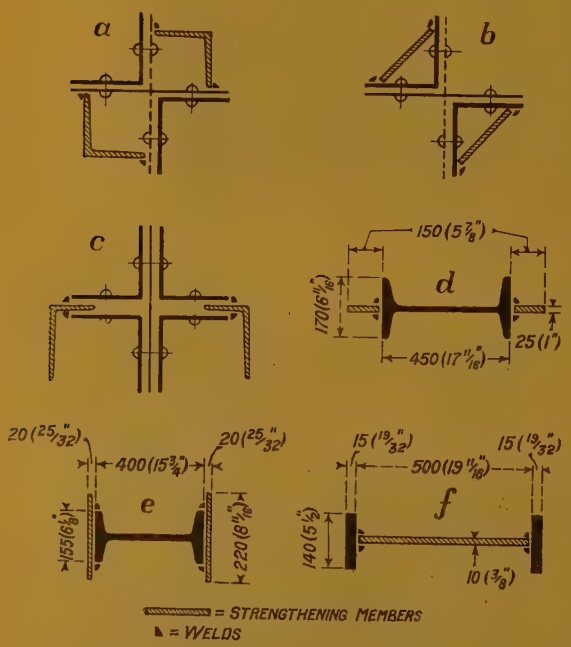


Fig. 6. — illustrating various methods of strengthening lattice members by welding.

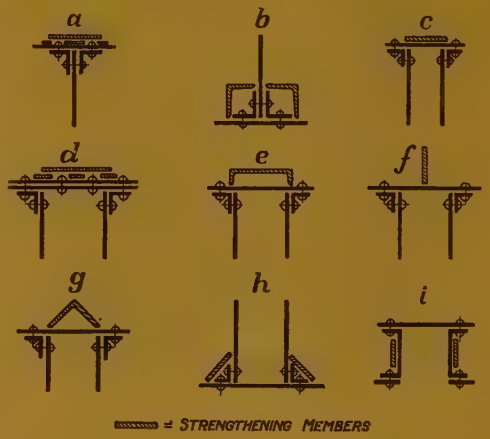


Fig. 7. — Typical examples of truss chords strengthened by welding. *b* and *h*, bottom chords; others, top chords.

Objections were formerly raised against many of these methods of reinforcement on the ground that the rivets ought to be left permanently accessible to inspection. It is now often recognised, however, that a covered rivet can be examined by X-rays if necessary, the requisite apparatus and technique having already been developed by some years of experience in railway applications. The welding-on of flats or angles is often specially effective, open sections being thus converted to closed sections resistant to buckling. Several examples of this are included in figures 6 and 7.

A remarkable instance of the strengthening by welding of a wide-span lat-

Fig. 8. — Wide-span lattice bridge strengthened by welding. (J. Gollnow & Sohn, Stettin.)

tice bridge with overhead platform is illustrated in figure 8. The end diagonals were reinforced by flats welded-on edgewise, and the gusset, which was cut curved, was augmented by a butt-welded sector-shaped piece as shown. The auxiliary vertical supports, built in before the strengthening was effected, were subsequently removed. There was also welded into the supporting joint of the frame a 20-mm. (25/32 in.) angle plate. as shown in figure 9. In order to fit this, the web of the strut was slotted and the new angle plate pushed through.

The application of an artificially produced force to unload the superstructure of a wide-span lattice bridge during the welding operation is illustrated by figure 10. A hydraulic press attached to one of the frame joints in the lower chord unloads the latter and the diagonals to an extent which is susceptible of accurate calculation. The cost of the strengthening provided in this case amounted to about 100 000 Rm. (approx.

Fig. 9. — Joint at the support of a lattice bridge (fig. 8), strengthened by welded-in angle plate.

Fig. 10 — illustrating use of hydraulic press to unload bridge members for welding. (J. Gollnow & Sohn, Stettin.)

Fig. 11. — X-ray examination of welds in the top chord of a lattice bridge. (R. Seifert & Co., Hamburg.)

Fig. 12. — Welders work on light scaffolding while strengthening single-track railway bridge over the River Oste, Wulsdorf-Stade. (Hummel & Merkel, Leipzig.)

£ 5 000 at par). In this connection it may be noted that, apart from the saving in cost compared with the new construction, a much higher proportion of the actual expenditure is on labour costs where strengthening is concerned (4).

(4) Sarrazin and Hoffmann, *Die Bautechnik*, Nos. 34, 36, 1933.

This is an attractive feature under prevailing conditions of unemployment.

Competent supervision of welders during the progress of strengthening operations is of the highest importance, but it is not necessary to rely on this alone. The completed welds can be examined by X-rays at any time and as often as may be desired. Figure 11 shows such examination in progress. The X-ray tube is mounted on a pillar between the upper chords, and the welds of the strengthened members are examined section by section.

Though many questions have still to be answered by further research, the practicability and advantages of strengthening railway bridges by welding are definitely established. In most of the principal industrial countries, many bridges thus strengthened have been in satisfactory service for a number of years.

[621. 33 (∝)]

Railway electrification in 1934.

(Electric Railway Traction, supplement to *The Railway Gazette.)*

The progress made in railway electrification during the past twelve months has been anything but discouraging. Fortunately, the possibilities of electrification are very widely appreciated and little difficulty appears to have arisen in raising the necessary capital, even for schemes of great magnitude.

Three-car train of compartment stock as used on the Liverpool-Southport line.

It is pleasing to be able to record that British railways and British manufacturers have taken a considerable part in the progress which has been made. The extension of the Southern Railway's electrified main lines from Wivelsfield to Eastbourne and Hastings, and from Bickley and Orpington to Sevenoaks, were recorded exactly twelve months ago, and such progress has been made

that electric traction over both routes to Sevenoaks has begun on January 6, 1935, and is expected to be opened to Hastings in May next. The short section from Bickley junction to St. Mary Cray was opened on May 1 last. Just a month ago, it was announced that the Southern intended to convert the Lewisham-Nunhead loop and the Woodside-Sanderstead line. When these schemes are completed, the Southern will have 447 route and approximately 1 160 track miles electrified, all on the 650-volt D.C. system.

The vast programme of the Southern has tended to overshadow the proposals of the London Passenger Transport Board for the construction of a new tube between Baker Street and Finchley Road, and the electrification of the old Metropolitan double-track line from Rickmansworth to Amersham. Farther north, the L.N.E.R. has in hand an extensive modernisation of the Tyneside electrified lines, and the Mersey Railway has also inaugurated a modernisation scheme for providing better facilities between Liverpool, Rock Ferry and Birkenhead Park.

Despite the £ 5 000 000 which has been spent on or allocated to railway electric traction in this country during 1934, the parlous state of the employment and railway financial questions on the Continent has given an impetus towards electrification proposals which, in France at least, are without parallel in the history of railways. The Marquet Plan, introduced by the Ministries of Finance and Public Works, provides for the expenditure by 1940 of 1 300 000 000 fr. on railway electrification, divided up as follows :

State : 403 million fr. for conversion of Paris-Le Mans line and certain suburban works as already detailed in the issues of *Electric Railway Traction* for July 27 and August 24.

P. O.-Midi : 470 million fr. for conversion of main line from Tours to Bordeaux; to be undertaken when the present electrification of the Vierzon-Brive line is completed. This is in addition to the electrification programme which the Midi has been carrying out for some years.

Est : 400 million fr. for conversion of suburban lines from Paris as far as Château-Thierry.

New train of aluminium-alloy cars on the Berlin suburban railways of the Reichsbahn.

P. L. M.: 27 million fr. for completion of the conversion work on the Culoz-Chambéry section of the Mt. Cenis international route.

In Germany, the Reichsbahn on October 6 opened to high-tension single-phase electric traction the 54-mile double-track line from Halle to Magdeburg, in Central Germany, and also the 30-mile Tubingen-Plochingen line in Wurtemberg. Extension of the Bavarian system is now being carried out on the 86-mile line from Augsburg to Nuremberg. Lines totalling 111 route miles have

Express train on the Bavarian electrified section of the Reichsbahn.

been converted to electric operation by the Swiss Federal Railways in 1934, the principal sections being those from Berne to Lucerne, and from Rorschach to Buchs. Little has been done in Austria except to push forward the work on the southern side of the Tauern inclines, but in Hungary the conversion of the Komarom-Hegyeshalom section of the Budapest-Vienna main line has been almost completed. During the year, the Metropolitan-Vickers Electrical Co. Ltd. shipped to the Hungarian State Railways a large amount of substation and locomotive equipment.

Several important lines have been opened in Italy following the adoption of the 4 200 000 000-lire scheme for general electrification introduced by the Minister of Communications in 1933. Both high-tension D.C. and three-phase A.C. systems have been extended, the most important of the converted lines under the former being the Naples-Salerno, and under the latter the Bolzano-Trento and Trofarello-Cuneo sections. These works, however, were overshadowed by the opening of the entirely new Bologna-Florence Direttissima, which is operated on the 3 000-volt

New station at Fredericksberg on the suburban electrified lines at Copenhagen.

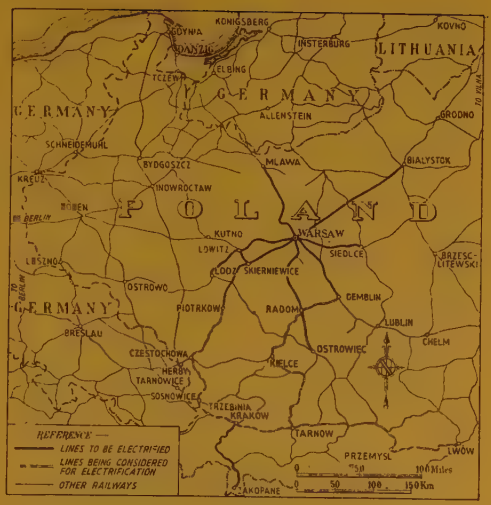
Overhead construction on a newly-electrified section of the Paris-Orleans Railway.

D.C. system. This line was described in the issue of *Electric Railway Traction* for May 4, 1934 (1).

Electrification is still proceeding apace on the lines of the Swedish State Railways, principally in the extension of the northern line from Hallsberg (on the Stockholm-Gothenburg route) to Krylbo and Aange, and on the west coast line from Gothenburg to Malmo. A beginning has also been made with the conversion of the line from Laxaa on the Stockholm-Gothenburg line to the Norwegian frontier at Charlottenberg, and two private lines, the Bergslagernas and Dalsand Railways, have begun the conversion of 140 route miles, which includes the main line from Gothenburg to the Norwegian frontier at Kornsjo. It is possible that the next few years will see an all-electric route between Stockholm or Malmo and Oslo, for the Norwegian State Railways have announced their intention of proceeding with the electrification of the Ostfold line, a work which has been proposed for a number of years.

Suburban extensions of electric working were made during the year on the Copenhagen system of the Danish State Railways, and the Rotterdam-Dordrecht section of the Netherlands Railways was electrified. Good progress has been made with the conversion by British firms of the lines round Warsaw, and at long last a definite move has been made with the electrification of the Madrid-Avila main line of the Northern Railway of Spain. Main-line and suburban electrification schemes have been pushed ahead in Russia, but despite the desire to build everything in Russian factories, high-power electric locomotives have been delivered from Italy within the last few months. In Belgium, rapid progress is being made with the conversion of the Brussels-Antwerp line, which is to be opened before the Brussels Exhibition in 1935.

(1) See also *Bulletin of the Railway Congress*, November 1934, p. 1249.

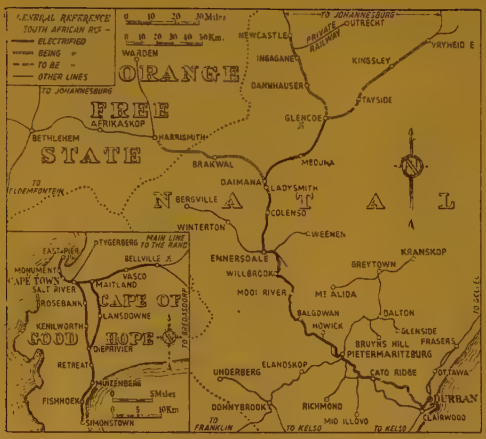


Map of lines to be electrified in Poland.

Extra-European countries.

So far as British interests are concerned, the outstanding event of the year was the virtual completion of negotiations between the Brazilian Government and the Metropolitan-Vickers Electrical Co. Ltd. for the conversion on the 3 000-volt D.C. system of the lines of the Central of Brazil Railway from Rio de Janeiro to Barra do Pirahy and Santa Cruz, a route mileage of 93 and a track mileage of 232. The estimated cost is in the neighbourhood of £ 3 000 000, but no practical progress hat yet been made, and apparently further difficulties have arisen.

Before the Granet Commission sailed for South Africa, the administration of the South African Railways had under conversion the Daimana-Harrismith section of the line from Natal to the Orange Free State, and this work is now almost completed. The administration also had under consideration the extension of electric working from Cato Ridge down



Map of electrified lines,
South African Railways.

to the sea at Durban, and this proposal was considered sound by the Granet Commission, which also recommended the extension of the northern end of the line from Glencoe to Volksrust, on the Transvaal border. Both of these lines are now being converted, but their working will not require additional generating plant or rolling stock.

Electrification of steam lines has also been proceeding in a lesser degree in Japan, and authority has been given for conversion of further lines in Algeria. In North America, the vast conversion programme of the Pennsylvania Railroad bestrides the narrow world of railway electrification like a Colossus. The project now nearing completion covers the electrification of all tracks between New York and Washington, a distance of 226 1/2 miles. The electrification of the passenger tracks is now over 80 % complete and the freight tracks approximately 50 %, and electric passenger operation is already in full swing over the 118 miles between New York and Wilmington, 27 miles south of Philadelphia. A number of lines in the Philadelphia, Newark and Trenton districts have been electrified for years, but the present

Five of the nine double-bogie 100-ton, 2 400-volt electric locomotives supplied to the Harbour Commissioners Railway, Montreal.

programme comprised the conversion of 232 route and 1 082 track miles to the 11 000-volt 25-cycle single-phase system.

Technical progress.

What time the electrified railways of the world have increased in quantity, the quality of the equipment has also advanced. In point of mileage the increase in high-tension D.C. systems has been balanced by single-phase extensions, notably in Germany, Switzerland, and the U. S. A., and the relative merits of A.C. and D.C. traction stand very much where they did a year ago, or for that matter, two years ago. In D.C. traction, mercury arc rectifier substations appear as if they will become universal for new work, and a development of the rectifier, the mercury vapour frequency converter, has made its appearance in single-phase traction, on the Baden section of the Reichsbahn. Other interesting developments of the year have been the success of carbon wearing strips for pantographs and the trial of steel contact wires in sidings and lightly-trafficked branch lines.

[656. 255 (.73)]

Centralized traffic control installed on the Alton Railroad.

(Railway Signaling.)

By installing centralized traffic control, consisting of an arrangement for directing train movements by signal indication on three miles of single track, the Alton has been able to improve train operation and effect a saving in operating expense.

Between Mazonia and South Joliet, 25 miles, the Alton has two single-track lines, the one via Pequot being a low-grade line used principally by through freight trains, while the more direct line is used principally by passenger trains. Between Pequot and Plaines, 16.1 miles, the freight line is parallel with the main line, of the Santa Fe, and for a number of years the two single-track lines of the two roads have been used jointly for double-track operation. In this arrangement the eastbound Santa Fe trains returned to the double-track Santa Fe line at Plaines. Likewise, the eastbound Alton trains operated over its own single-track line between Plaines and South Joliet. On the other hand, westbound Alton freight trains were required to enter the Santa Fe double-track at Joliet, and operate on this line to Pequot. This

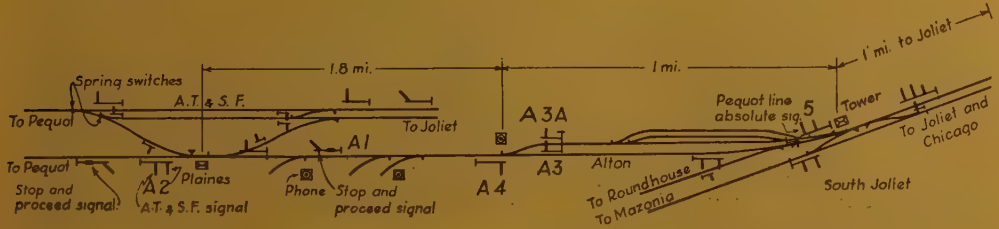


Fig. 1. — Track and signal plan of centralized traffic control installation.

operation was necessary because there was no westbound connecting track between the Alton and the Santa Fe at Plaines. Recently such a connecting track was constructed at Plaines, as shown on the plan below, and, therefore, the Alton can now run its westbound as well as its eastbound freight trains, on its own line between Joliet and Plaines.

The traffic now handled on this section of single-track includes about nine freight trains and one passenger train each way daily, in addition to a switching train which operates on this territory about one hour daily to serve the industries. Therefore, if this territory were operated as single track, under time tables and train order, numerous delays would result. It was, therefore, decided to install a simple arrangement for directing train movements in either direction by signal indication, thus constituting a centralized control (C. T. C.) system.

At the east end of this project, South Joliet, the Alton has a 28-lever mechanical interlocking, which includes the crossovers and switches for the junction of its two single-track lines with the double-track line to Chicago, as well as switches leading to the yard and to the enginehouse. It was, therefore, convenient to locate the control machine for the C. T. C. system in the tower of this interlocking and have it operated by the leverman.

At the west end of the project, Plaines, there is an office with an operator on duty who operates the hand-throw switch, near the office, leading from the Alton track to the Santa Fe main line. A desk-lever control arrangement was also in service in this office for the control of the power-operated switch at the east end of the Santa Fe passing track, as well as to control the various signals. When the new westward connecting track between the Alton and the Santa Fe track was constructed, it was arranged for this operator to operate the hand-throw switch at the east end of this connection, as it was also located near the office. In order to prevent this switch from being reversed when a westbound Santa Fe train is approaching, an electric switchlock was installed, the control of which extends for two full automatic blocks on the westbound Santa Fe tracks. At the west end of this connection, a spring switch was installed for the main line switch as well as for the Santa Fe passing-track switch.

With this track layout and means of operating the switches, the next problem was to arrange the signals for directing train movements. At South Joliet, westward interlocking signal No. 5 was previously used to direct trains on the main line. As this signal was properly located to be used for directing train movements, the top mechanically-operated arm was replaced by a motor-operated semaphore, and the controls were revised to include the C. T. C. control features required.

Another problem was introduced by the fact that a large percentage of the freight trains stop at the South Joliet yard to pick up and set out cars. Furthermore, the track just north of the main line in this yard is used as a passing siding. In view of these conditions, some arrangement was necessary to protect and to direct train movements when entering or leaving the main line via the switch at the west end of this yard. Therefore, as shown on the plan, an eastward and a westward absolute signal, as well as an absolute signal leading off of the passing track, were installed at this switch, the two westbound signals being located on a cantilever bridge. The use of these controlled signals results in the block between South Joliet and Plaines being cut in two sections, which has proved to be a decided advantage because a westbound train can be started out of South Joliet while an eastbound train is going from Plaines to the west switch. Trains can thus meet

and pass under full automatic-block protection and with the movements directed by signal indication.

At Plaines, the eastward home signal *A2* has two arms, the top arm governing to the Alton single track, while the lower arm governs over the diverging route leading to the Santa Fe. In order to use the top arm of this signal to direct train movements as a part of the new C. T. C. system, the control was revised, the new feature being that the control of the proceed aspect depends also on the position of the C. T. C. lever at South Joliet.

It should be noted that all of the absolute signals used for directing train movements are semi-automatic, the control being selected through track circuits and switch circuit controllers in the usual manner, thus retaining the automatic safety features of control, onto which is incorporated the C. T. C. control of the proceed aspects.

In order to accommodate the switching train, a telephone is located at each of the main spur-track switches. When a train leaves the main line to serve some industry, it cannot again return to the main line or throw a switch until the conductor calls the leverman at South Joliet and gets permission to do so.

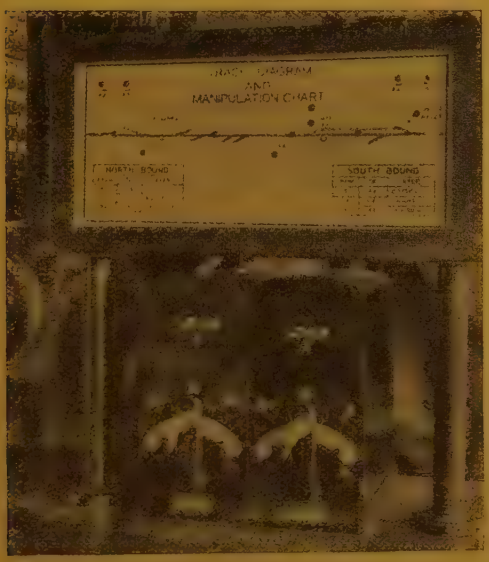


Fig. 2. — The illuminated track diagram and levers are mounted on the operator's desk.

The control machine.

As shown in the illustration, the C. T. C. control machine, in the tower at South Joliet, consists of two G. R. S. desk levers and illuminated track and signal diagram. Each lever operates to three positions, being normally on center. When lever No. 2 is thrown to the left, it controls signal *A4* and when thrown to the right it controls opposing signal 5. Likewise, lever *1* controls signal *A2* and *A3*. The position of the west yard switch selects between the signal on the main line, *A3*, and the one on the siding, *A3A*. It should be noted that as a lever in one position controls one of two opposing signals, the interlocking between the two signals is thus accomplished automatically, because a lever, of course, can be in only one position at any one time. There is, therefore, no mechanical locking or electric locks on the levers, the leverman being able to operate them at any time he sees fit. Direct stick locking is used; when a signal is cleared, a stick relay is dropped and if a train does not accept the signal, a time release, set at two minutes, must be operated to effect a release. The fact that the stick control is set up is indicated by the illumination of a small lamp marked « S », one such lamp being provided on the diagram for each signal. Each lamp has an arrow indicating the direction in which traffic is set up. As an indication that a signal has cleared, to correspond with the position of the lever, there is a small green lamp adjacent to the symbol representing each signal on the diagram.

When lining up for a westbound train, the interlocking must, of course, be lined

up to clear signal *5*, and lever No. 5 in the mechanical interlocking is reversed. However, the signal does not clear until the lever in the C. T. C. machine is thrown. Likewise, when an eastbound Alton train approaches Plaines, the operator at that station operates his lever, controlling signal *A2*. An approach light and annunciator is provided on the C. T. C. diagram so that the leverman at South Joliet is informed of the approach of the train so that he can also operate his C. T. C. lever and then signal *A2* will clear. The annunciator for the South Joliet board is selected through the controller on the switch at Plaines, so that only Alton trains are announced, provided the operator at Plaines has the switch lined up before the train enters the annunciator circuit. Telephone communication between the two offices is available to convey information, if necessary, when arranging for line-ups. In addition to track-occupancy lamps on the diagram and annunciators for all approaches, lamps are provided for all track sections between South Joliet and Plaines so that the leverman knows the location of all trains on the territory. The leverman at South Joliet keeps a train sheet to record the time each train passes South Joliet and Plaines.

As a result of the construction of the new connecting track at Plaines and the installation of the C. T. C. for directing train movements, the Alton has not only reduced operating expenses but has also expedited the movement of its trains. One item of expense eliminated was the payment for the use of the Santa Fe track for westbound Alton freight trains between Joliet and Plaines. Furthermore, under the previous arrangement, cars in the South Joliet yard, that were to be sent westward, had to be handled by a switch engine back to Jackson Street yard in Joliet. On account of the adverse conditions of track layout and grades, as well as delays occasioned by getting through the interlockings, a westbound Alton freight train usually lost about 30 minutes in picking-up and setting-out cars at the Jackson Street yard. With the new arrangement, cars can be set-out and picked-up at the South Joliet yard in about 10 minutes. Thus a saving of about 20 minutes is made for each westbound Alton freight train. Furthermore, the transfer of cars back and forth between South Joliet and the Jackson Street yard has been eliminated.

The operation of trains by signal indication under the C. T. C. arrangement has been highly satisfactory, the system being so flexible as to permit movements to meet conditions as they arise with a minimum of delays.

The line control circuits for this installation are simple; a two-wire circuit extends from the tower to Plaines to control the HD relay of signal *A2*, and another such circuit is used to control each of the HD relays for signals *A4* and *A3*. The diagram lamps indicating the position of each of these signals is controlled through a G. R. S. type-W relay at the South Joliet tower connected in series with the line circuit. A line circuit operating a retained-neutral polar relay is used to convey indications of the approach of Alton trains at Plaines, as well as the indication of track occupancy between Plaines and the west yard switch.

Between Plaines and the west switch, these circuits are in open lines, using No. 10 copperweld wire with weatherproof covering. Between the west switch and South Joliet tower, a 16-conductor Okonite aerial cable was installed, this being carried on the pole line and suspended by Western Railroad Supply Company cable straps from a stranded messenger. All cable wires coming into the tower are terminated on Premier No. 3 W. R. S. Co. arresters.

At the time the C. T. C. was installed, the wiring of the South Joliet interlocking was overhauled and all the relays

and battery were located in a new cabinet in the lower floor of the tower. The relays are of the wall type with spring suspension.

A set of five Exide EMGO-5 lead storage cells is used for the C. T. C. line circuit. As a part of the reconstruction, a new central battery of 6 cells of Exide EMGO-7 type battery was provided for operation of all of the electrically-operated semaphore signals on the mechanical interlocking. This idea of using one battery for this purpose, with No. 6 copper wire to the various signals, eliminates the necessity for a separate battery at each home signal location, and also effects economies in charging.

Fig. 3. — Signals located at west end of Alton passing track.

In order to charge the batteries mentioned, a new Union type-W-20 transformer was installed, together with Union RX-11 rectifiers. Each storage-battery circuit is fused to protect the battery in case of an accidental short circuit.

The desk levers used for the C. T. C. control, as well as the signals and relays on this installation, are of General Railway Signal Company manufacture. The illuminated track diagram was made by the Alton signal department, using Western Electric No. 13 switchboard lamp sockets, equipped with No. 2 lamps and lamp caps. The installation was planned and constructed by the signal forces of the Alton.

[656. 254. (.43)]

Automatic train control on the German State Railways.

Extensive installations of the inductive system.

(The Railway Gazette).

Intermittent inductive automatic train control is already in use on several important main line routes of the German State Railways and is to be extended to others during the present year, as indicated on the accompanying map (fig. 1). About 125 locomotives and 2 600 km. (1 615 miles) of track are now equipped, including the Berlin-Hamburg section and the express diesel cars running thereon. The track equipment also exists between Hamburg and Bremen, but the apparatus has not yet been extended to all the locomotives running on these sections. Many more, however, are to be equipped during the next twelve months. It will be seen from the map that the routes selected for further equipment are of considerable length, and are among those over which the fastest trains are run.

The earliest experiments in Germany with automatic train control and cab-signals date back many years. One of the most interesting devices experimented with was the electro-magnetic apparatus of C. Stahmer, Georgsmarien-

hütte, which was installed between Münster and Osnabrück. In that case a powerful permanent magnet was mounted over the track and acted on receiving apparatus attached to the locomotive cab roof. Just before reaching a distant signal, whether « on » or « off », the driver received a visual warning in the

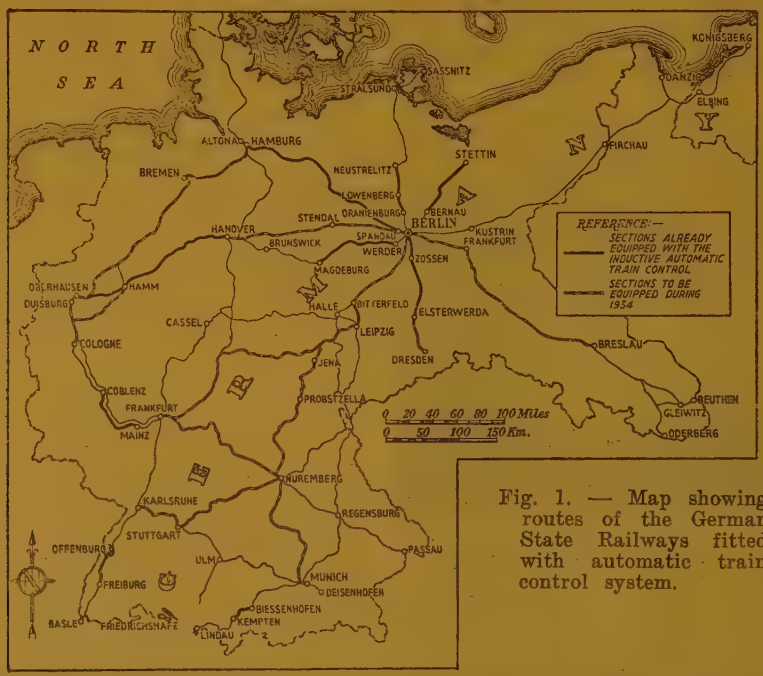


Fig. 1. — Map showing routes of the German State Railways fitted with automatic train control system.

cab and a bell rang until he pressed a push-button. The Van Braam mechanical apparatus, of the Bruchsal works, and the electrical ramp contact apparatus of the Siemens and Halske type were also tried. Since the war, partly on account of some rather bad accidents which have occurred, the subject has been again taken up and many further experiments made. On the Berlin electric local lines a mechanical train-stop has been installed at practically all stop signals, but for the fast express routes the inductive principle has found most favour, although the Bäseler-Zeiss optical system is also being experimented with still. In 1925, the Reichsbahn drew up a programme of requirements for inductive automatic train control to serve as a guide to the signal manufacturing firms, and this, with some modifications indicated by experience, is still in force. The chief reasons for the choice of inductive transmission were immunity from climatic interference and absence of moving parts on the track, with the fact that no source of current is required along the line and that the maintenance is practically confined to the parts on the locomotives. It is also easier to adopt inductive apparatus in conjunction with light signals, whereas mechanical train-stops need motors of some sort to operate them.

The first principle laid down by the Reichsbahn is that the driver shall be

left free to manage his train and shall be held fully responsible for doing so, the train control apparatus only coming into operation if he fails in his duty. The second principle adopted is what is called the vigilance principle, that is to say the driver is obliged to observe the distant signals along the line and signify that he has done so by operating the vigilance button within five seconds after passing one, which action is recorded. Should he neglect to do so, an automatic brake application will begin after this time interval has elapsed. Temporary warning discs placed by the permanent way staff can also be made to produce this effect. Should a home signal be over-run, a full brake application is produced, which cannot be cancelled until the train has come to a stand. In addition, a speed-checking control is fitted which causes a brake application to come into action ten seconds after passing an adverse distant signal if the driver has not by that time reduced speed to a predetermined figure, and this arrangement can also be applied near curves and other places where speed should be reduced.

Working of the apparatus.

Figure 2 shows the layout of the locomotive equipment. On the side of the

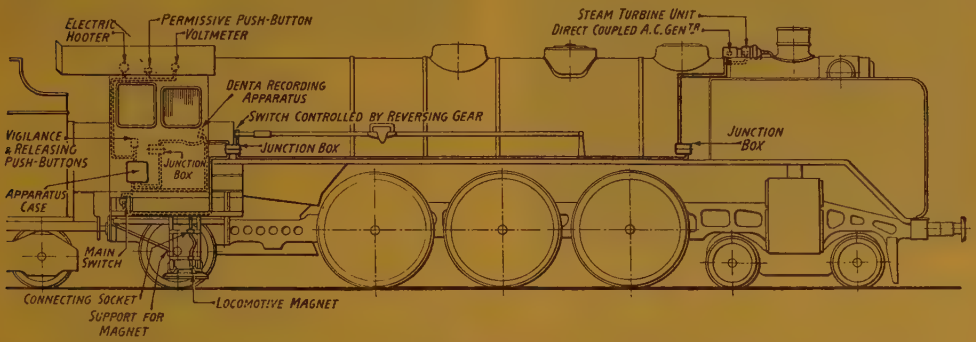


Fig. 2. — General arrangement of apparatus on express locomotive.

Fig. 3. — Locomotive magnet passing over track magnet. On the right below the framing the cut-out cock.

engine, a short distance above track level, is supported the locomotive magnet, seen also in figures 3 and 4, which carries three windings energised as resonant circuits tuned to frequencies of 500, 1 000 and 2 000 cycles, from a turbo-generator set on the boiler. The three frequencies correspond to the absolute stop, distant signal and speed control effects respectively, and in each circuit on the locomotive there is a normally energised relay which in turn controls the other apparatus. An electric hooter sounds whenever any essential part becomes defective, or when the brakes are applied independently of the driver. To pass a stop signal at « danger, » in case

Fig. 4. — Latest arrangement of locomotive magnet.

of unavoidable necessity, the driver operates a special push-button, normally sealed, which action is recorded. The fittings on the locomotive are made specially robust. The relay units are arranged with jack connections, and the wiring is run in steel tubing lined with insulating material. A cut-out switch is provided to put the apparatus out of action if special circumstances necessitate this.

Magnets are placed beside the track, as seen in figure 3 and figure 5, tuned respectively to the frequencies mentioned above and connected electrically to the signals as shown in figure 6, their condensers being short-circuited when the signals are « off ». When the signals are « on » and a locomotive magnet passes over a track magnet, the reaction

Fig. 5. — Three-indication distant signal with track magnet. (The signal indicates that a reduced speed is called for at the home signal.)

between the two resonant circuits causes a momentary reduction of the current in the circuit on the train, releasing the corresponding relay and producing the appropriate control effect. The signal department staff is supplied with special testing sets for seeing whether the track magnets are in proper order. As indicated in figure 7, the express diesel trains are fitted with the equipment and

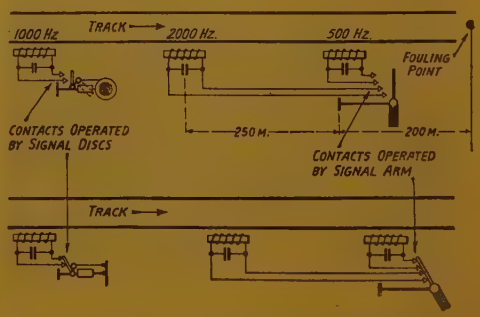


Fig. 6. — Electrical connections between track magnets and signals.

Fig. 7. — Magnet on diesel railcar.

Fig. 9. — Deuta speed recorder instrument.

Fig. 8. — Driver's cab on the Flying Hamburger. (Vigilance releasing and permissive push-button seen above hand brake wheel.

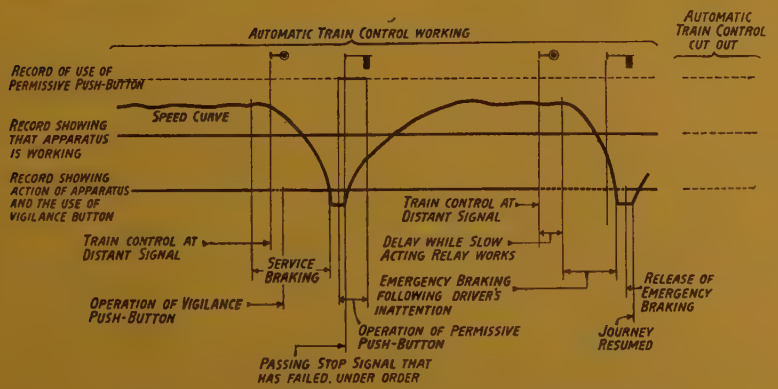

AUTOMATIC TRAIN CONTROL WORKING
AUTOMATIC TRAIN CONTROL CUT OUT
RECORD OF USE OF PERMISSIVE PUSH-BUTTON
SPEED CURVE
RECORD SHOWING THAT APPARATUS IS WORKING
RECORD SHOWING ACTION OF APPARATUS AND THE USE OF VIGILANCE BUTTON
TRAIN CONTROL AT DISTANT SIGNAL
TRAIN CONTROL AT DISTANT SIGNAL
DELAY WHILE SLOW ACTING RELAY WORKS
SERVICE BRAKING
EMERGENCY BRAKING FOLLOWING DRIVER'S INATTENTION
RELEASE OF EMERGENCY BRAKING
OPERATION OF VIGILANCE PUSH-BUTTON
OPERATION OF PERMISSIVE PUSH-BUTTON
JOURNEY RESUMED
PASSING STOP SIGNAL THAT HAS FAILED. UNDER ORDER

Fig. 10. — Record taken by Deuta speed recorder.

no difficulty has been experienced with the working at the highest speeds. Figure 8 shows the interior of the driver's cab on the « Flying Hamburger ». The

vigilance and releasing buttons can be seen on the controller casing just above the hand brake wheel.

Recording apparatus.

The Deuta speed recording apparatus, shown in figure 9, is used in conjunction with the automatic train control and it makes a continuous record during the run in the form shown in figure 10. The speed of the train, the condition of the control apparatus, either in or out of service, and the various effects that take place are recorded, together with the operation by the driver of the vigilance, releasing and permissive push-buttons.

The above particulars show that the German State Railways have devoted close attention to the automatic train control problem and, in association with the leading signal manufacturers, have developed a system of a very complete character. The details relate to the installations made to date, but some small modifications are now contemplated in those about to be put in hand, to which we hope to refer in a later issue. The general principles adopted are, however, in no way affected.

RECENT DEVELOPMENTS.
IN RAILWAY PRACTICE.

[656. 222.4 (.45)]

Increasing the capacity of a suburban railway,

by Ad. M. Hug, Consulting Engineer, Thalwil-Zurich.

The capacity of a suburban railway can be increased in many different ways, some of which are described below :

1. *Alterations to the fixed plant :*

doubling single or even existing double lines;

electrification when there is a frequent service of heavy trains, or heavy peak traffic;

increasing the number of platforms in terminal stations.

2. *Alterations limited to the rolling stock :*

lengthening the trains;

introducing push and pull trains;

using more powerful locomotors to permit quicker acceleration and deceleration;

raising the speed (1); etc., etc...

Most of these methods, especially those under (1) involve structural alterations and heavy expenditure, and possibly considerable additional capital investment.

Now, under present-day conditions, in order to meet the public demand for improved facilities, to cover peak traffic, and to fight competition from other forms of transport, especially road transport (road motor omnibuses), the capacity of the equipment available must be increased without any great increase in capital expenditure, that is to say *without heavy expenditure on construction and equipment.*

The Rome-Ostia railway, operated by the Società Elettro-Ferroviaria Italiana (S.E.F.I.), is a typical and interesting example of this kind (2).

The author witnessed the trials carried out to see how the capacity of this railway, connecting Rome with the sea, could be increased.

This railway handles a fairly heavy suburban passenger traffic between Rome and its south-western suburbs; besides, and especially in the summer season and on holidays, large numbers of people are carried to the seaside at Ostia.

The line, which starts from Rome (Porta-S. Paolo station) and ends at Ostia itself, is 25 km. (15.5 miles) long and double-tracked throughout. Figure 1 shows the gradient section. The line was built between 1920 and 1924, and was electrically operated from the be-

(1) Increased speed is mentioned last because in itself it is not of great importance in suburban working, owing to the short distances and frequent stops.

(2) See *Rivista Tecnica delle Ferrovie Italiane* (15th May, 1927), article by L. Soccorsi, Manager of the Company : « La ferrovia elettrica Roma-Ostia » (the Rome-Ostia Electric Railway).

ginning at 2 600 volts D.C. picked up from overhead equipment.

In 1932, and 1933 especially, owing to the heavy extra traffic due to the Holy Year and the Fascist Exhibition, the operating company, which at the same time owns the Pier and Casino at Ostia, had to consider how to increase the

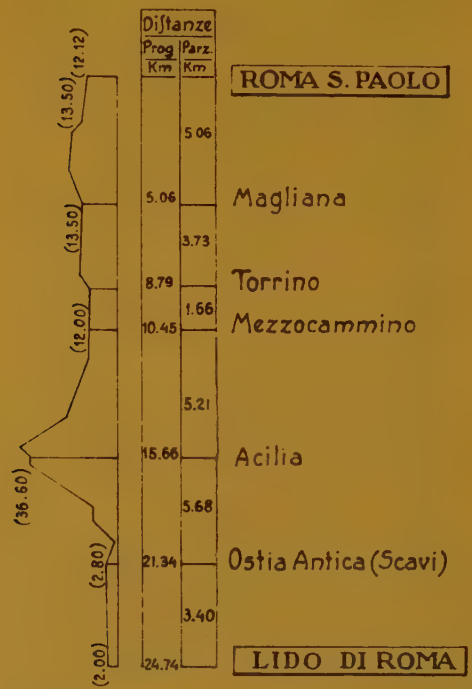


Fig. 1. — Rome-Ostia line gradient section. Maximum gradients : 1 in 52 for 0.6 km. (0.37 mile) and 1 in 62 for about 2 km. (1.24 miles).

Note. — Scavi = Excavations.

capacity of the line. Figure 2 shows the train working diagram for the 1933-34 winter season; the great number of services will be noticed; in summer the traffic to a seaside resort is, of course, still much heavier.

The stations were originally built on a generous scale in order to meet probable traffic increases, with an ample number of platforms (see fig. 4), the

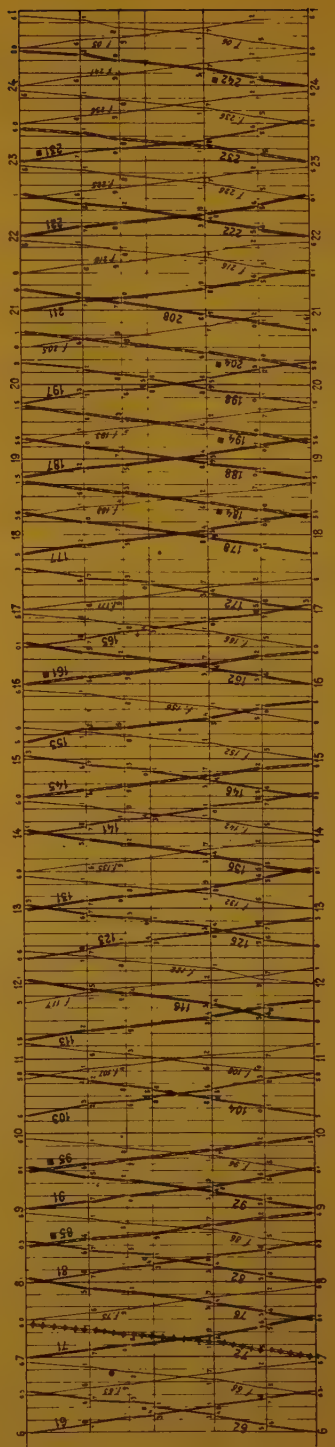


Fig. 2. — Train working diagram, 1933-1934 winter.

Legend : ——— stopping trains; ▬▬ accelerated trains; =■=■=■= through trains ; = ■ = ■ = through trains (sundays and general holidays).

Average journey time : 28 minutes approx.

platforms being raised to speed up filling and emptying the trains. Moreover, the capacity of the rolling stock was practically sufficient for the present traffic offered. Consequently the two inexpensive methods by which the capacity of the line could be increased were :

1. using push and pull trains, and
2. increasing the speed.

Apart from five low-powered rail motor coaches, the traffic is almost entirely worked by 8 (9) B_0-B_0 type electric locomotives (fig. 3), weighing 25 tons empty, and hauling trains usually made up of 6 bogie vehicles of uniform design (fig. 4).

The first question to tackle was how to increase the speed, and the second to see if, at the higher speed considered (or even at the speed then worked to), the rakes could be made into push and pull trains, i.e. be worked with the locomotor either hauling or pushing the stock.

As regards higher speed, the vehicles in use, which were the usual type of suburban carriage (figs. 4 and 5), had to be examined to see if they were suitable for running at higher speeds, and especially to make sure they could be run in front of trains pushed by a locomotor. The usual type of bogie used under these trailer vehicles is shown in figure 5. The inspection of this stock and the subsequent trials showed that the speed could very well be increased from 65 to 80 km. (40.4 to 50 miles) and that the vehicles could be run at the front end of the trains provided, of course, they were fitted with multiple-unit control. Two minor alterations had to be made to the stock before it could be put into service :

a) the couplings had to be shortened, as stock in push and pull trains has to be tight-coupled, and the couplings in actual use were too long to give the desired buffer compression;

b) the clearance between the flanges and the rails had to be reduced to ensure good riding at the higher speeds, especially with the locomotor pushing.

Now this line, like most Italian railways built at the same period, was laid to 1 445-mm. (4 ft. 8 7/8 in.) gauge, i.e. 10 mm. (3/8 inch) wider than the standard European gauge of 1 435 mm. (4 ft. 8 1/2 in.).

The wheel play could be reduced either by moving one or both wheel centres outwards on their axle, or by closing in the gauge by 10 mm. (3/8 inch). Now, the Italian Government some years ago decreed that all 1 445-mm. (4 ft. 8 7/8 in.) gauge lines were to be altered progressively to the 1 435-mm. (4 ft. 8 1/2 in.) gauge. The Rome-Ostia railway, which is connected to the Italian State system, was being reduced to the 1 435-mm. gauge and this reduced the clearance between the flanges and the rails by 10 mm., as the rolling stock built for the 1 445-mm. gauge was not altered. The riding quality of the stock was greatly improved thereby.

As regards the locomotors, they were originally designed to develop 900 H.P. at the hourby rating, and to work the usual trains of six loaded vehicles weighing 180 to 190 tons at 60 to 65 km. (37.3 to 40.4 miles) an hour on the level. Any much higher speed was therefore impracticable, as the motor armature speed would be excessive, apart from the higher power required. Altering the gear ratio would not have been sufficient, as it would have reduced the tractive effort for an equivalent rating.

A few more powerful locomotors, designed for higher speed, were therefore required, at least for handling the heavy traffic on certain days, and these locomotors moreover were to be fitted for multiple-control operation. A number of coaches with driving compartments, and of rather heavier weight than the standard type, for running at the leading end of the train, were also needed.

Fig. 3. — 900-H.P. B_0-B_0 type locomotor, for 2 600-volt D. C.

Photos : Ad. M. Hu

Fig. 4. — Standard train (locomotor and 6 trailer at the Ostia terminus.

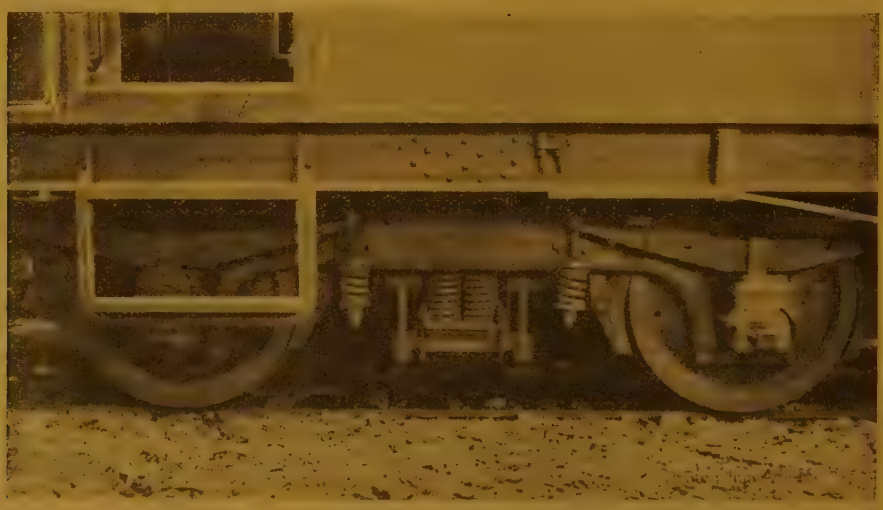


Fig. 5. — Carriage bogie showing triple springing, and the very low bolster position.

One 1 200-H.P. (hourly rating) locomotive, for a maximum speed of 80 km. (50 miles) per hour, and one driving coach as described above, were ordered during the 1933-1934 winter, and will shortly go into service for trials, the results of which, it is expected, will be definite and conclusive.

During the 1933 spring, preliminary trials were carried out, during which the speed was increased progressively to 90 km. (56 miles) an hour and above,

with the locomotor first hauling and then pushing the train. Owing to lack of power, the train (empty, of course) had to be reduced to 5 and then to 4 vehicles. The riding of the coaches was excellent throughout the trials, and no defects developed either during or after them.

The extent to which the weight of the coaches can be reduced economically, i.e. light-weight vehicles substituded, should be investigated and also whether, by using lighter vehicles, trains of equal capacity can be worked at higher speed by merely altering the gear ratio of the locomotors.

Another possible method would be to slightly alter the existing stock and streamline it. The reduction in air resistance would mean an increase in the power of the locomotors, which would, of course, also be streamlined by means of light plates, especially at the front end and over the wheels.

This method, although somewhat special, is still to be considered and the question will be to ascertain if the alteration to the outside form of the stock would reduce the air resistance sufficiently (for a speed increase of about 40 %) to compensate for the greater power otherwise required.

This instance of increased capacity of a line is particularly interesting as showing how the working conditions can be improved without heavy capital expenditure and the operating costs reduced at the same time by using push and pull trains and stock of lighter weight.

MISCELLANEOUS INFORMATION.

[621 .132.5 (.43)]

1. — New 2-10-0 goods locomotives for the German State Railways.

(*The Railway Gazette.*)

The German State Railway Company ordered last year several new types of locomotives distinguished by the use of boiler pressures of 25 atmospheres (355 lb. per sq. in.). Two 2-10-0 four-cylinder compound engines, intended for heavy goods service in mountainous country, were recently delivered by Henschel & Sohn A. G., Cassel, one of them, it may be noted, being the 22 000th machine to leave these works. The design and construction of the new locomotives were undertaken in close co-operation with the railway, and special high-tensile steels were adopted for the boilers in view of the high steam pressure employed. Compared with the standard goods locomotives of the Reichsbahn, the four-cylinder compound engines show an increase in tractive effort of 10 to 15 %, and they are capable of a maximum speed of 80 km. (49.7 miles) an hour.

As will be seen from the accompanying photograph, the motion and other working parts are readily accessible.

The tender is of the eight-wheeled type, weighing about 32 tons empty and 73 3/4 tons in working order. The total weight of engine and tender in working order thus amounts to about 186 1/2 tons, making these the heaviest locomotives at present in use on the German State Railways. The special equipment includes two thermic syphons in the firebox and a complete installation of electric lighting. Before being taken into regular service, these machines underwent numerous trials at the Grünewald research station, with completely satisfactory results.

The leading dimensions of the locomotives are :

Cylinders, diameter, h.p.	420 mm. (16 1/2 in.).
» » l.p.	680 mm. (26 3/4 in.).
» stroke	660 mm. (26 in.).
Coupled wheels, diameter	1 400 mm. (4 ft. 7 in.).
Bissel wheels, diameter	1 000 mm. (3 ft. 3 1/2 in.).
Boiler working pressure	25 atm. (335 lb. per sq. in.).
» heating surface, tubes and flues	203.0 m² (2 184 sq. ft.).
» » » firebox	22.2 m² (239 sq. ft.).
	225.2 m² (2 423 sq. ft.).
» » » superheater	124.7 m² (1 342 sq. ft.).
Total	349.9 m² (3 765 sq. ft.).
Grate area	4.7 m² (50.6 sq. ft.).
Wheelbase, total engine	9 650 mm. (31 ft. 8 in.).
Weight of engine in working order	114.5 t. (112 3/4 Engl. tons).
Adhesion weight	100.0 t. (98 1/2 Engl. tons).
Tender, weight in working order	75.0 t. (73 3/4 Engl. tons).
Water capacity	32 m³ (7 040 Br. gall.).
Fuel capacity	10 t. (9.85 Engl. tons).

[621. 132.3 (.437)]

2. — New three-cylinder 4-8-2 express locomotive, Czechoslovakian State Railways.

(The Railway Gazette.)

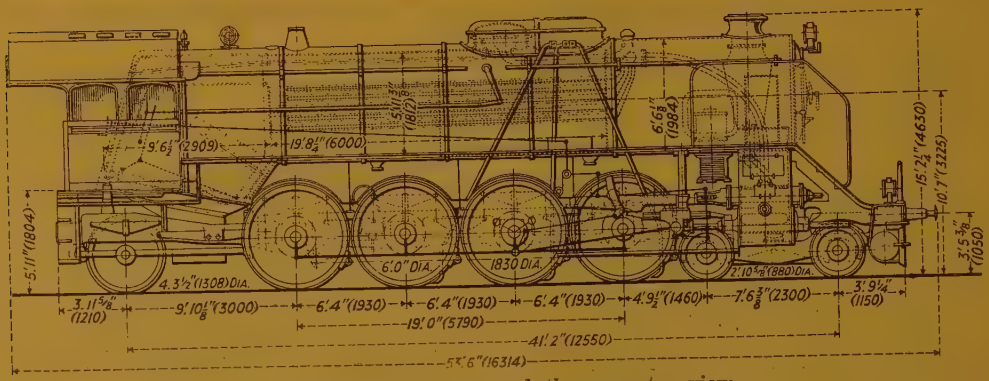
A new type of powerful express locomotive has recently been introduced on the State Railways of Czechoslovakia, having the 4-8-2 wheel arrangement and three single-expansion cylinders, and by courtesy of Ing. Karel Fasse, Chief of the Rolling Stock Department, we are enabled to reproduce a dimensioned drawing and photograph of the first of the new series. Locomotives of a more powerful type were required for working express trains over the heavily graded sections of the State Railway system, and the demand was for an engine capable of developing a high tractive effort and rapid acceleration rather than one having the ability to run at extra fast speeds. Consideration has also been given to the matter of flexibility on curves and, although the engine has four coupled axles, the rigid wheelbase is restricted to 19 feet in relation to a total wheelbase of 42 feet, it being desired that curves having a radius of 490 feet could be traversed without difficulty. The bogie is designed for a side play of 3 1/8 inches on either side and a pressure of 8 800 lb. is utilised for keeping it central; with the maximum displacement the centering force is 15 400 lb. The flanges of the first and last pairs of coupled wheels are turned 3/16 inch under size, while those of the two intermediate pairs of coupled wheels are reduced by 3/8 inch. A similar amount of flexibility is imparted to the trailing axle as in the case of the leading bogie.

The three cylinders are arranged so that those outside are horizontal and the inside one is inclined at 1 in 10. The cylinders are cast of vanadium steel with cast iron bushes, and have bye-pass valves of the poppet type which are automatically closed when the regulator is open. Steam distribution is effected by Walschaerts type valve motion with inside admission, and each piston valve is operated by a separate set of valve gearing.

The piston valve bodies are constructed of steel and fitted with narrow cast iron rings and the links are suspended on S. K. F. roller and ball bearings. Return cranks attached to the main crank pins are utilised in the ordinary way for the valves of the outside cylinders, whilst that of the inside cylinder is actuated by a return crank attached to the outside crank pin of the third pair of coupled wheels on the left hand side of the engine. The transmission shaft is carried in two bearings and transmits the motion to the inner link, and all three die blocks are actuated by one reversing shaft carried in three bearings.

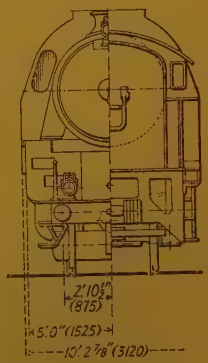
The boiler has an external diameter of 6 ft. 7/8 in. and carries a working pressure of 227 lb. per sq. inch. It is fitted with a superheater having 35 elements, and the distance between the tube plates is 19 ft. 8 in. The 35 smoke tubes have a diameter of 6 inches and there are 126 fire tubes 2 1/4 inches diameter. The grate area is 52 sq. feet. The grate is provided with a drop section, counterbalanced by a spring, and the grate bars, which are of iron, are subjected to an aluminium treatment to increase their heat resisting qualities.

The engine in working order weighs 102 1/4 tons and when empty 93 1/4 tons. The « normal » adhesion weight is 63.85 tons, but this can be increased to about 70 tons by an arrangement which permits of altering the equalisers. The springs of the coupled axles and those of the bogie are compensated and arranged so that the engine has three-point suspension. The sandbox is incorporated with the dome casing and compressed air is used for propelling the sand to the rails in front of each of the first three pairs of coupled wheels. The engine is fitted with Westinghouse air brake with Nielebock-Knorr compressor, the brake being applied on the front of all coupled wheels. The fittings include an exhaust steam injector, a non-lifting injector,



Dimensional drawing and three-quarter view.

A separate return crank on the third pair of coupled wheels is used for the inside cylinder piston valve.



Combined end views.

and a Haushalter-Teloc speed indicator. There is a 350-watt turbo-generator on the top of the boiler for supplying current for the head lamps, for lighting the cab, water gauges, etc., and for illuminating the valve motion for inspection purposes.

The following are the principal particulars :

Cylinders (3) diameter . .	21 5/8 in.
Piston stroke	26 3/4 in.
Wheels, coupled, diameter .	6 ft. 0 3/4 in.
» leading bogie, diam.	2 ft. 10 3/4 in.
» trailing diameter .	4 ft. 3 5/8 in.
Wheelbase, engine	42 ft. 0 in.
Wheelbase, rigid	19 ft. 0 in.
Boiler working pressure .	227 lb. per sq. in.
Heating surface : — fire-box and arch tubes . .	213.5 sq.ft.
Tubes	2.529.6 »
Total	2.743.1 »
Superheater	968.7 »
Combined total	3.711.8 »
Grate area	52 »

The tender, of standard Czechoslovakian State Railway design, runs on eight wheels. The locomotive, which was manufactured by the Skoda Works at Pilsen, presents a very fine appearance, as we are able to testify, having recently had the opportunity of inspecting it at the Wilson station in Prague.

[621. 132.6 (.44)]

3. — Three-cylinder simple-expansion 2-8-2 tank locomotives for suburban trains, Est Railway, France.

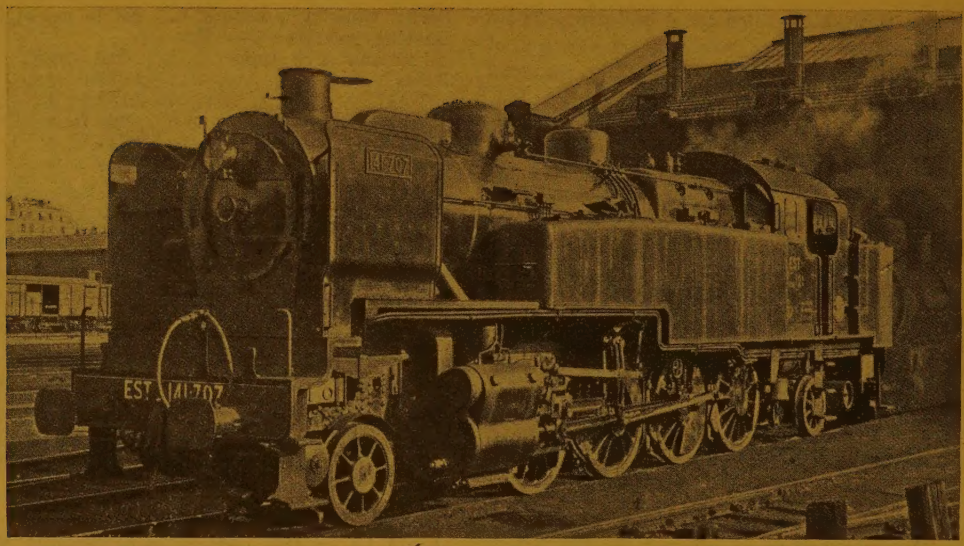
(The Railway Gazette.)

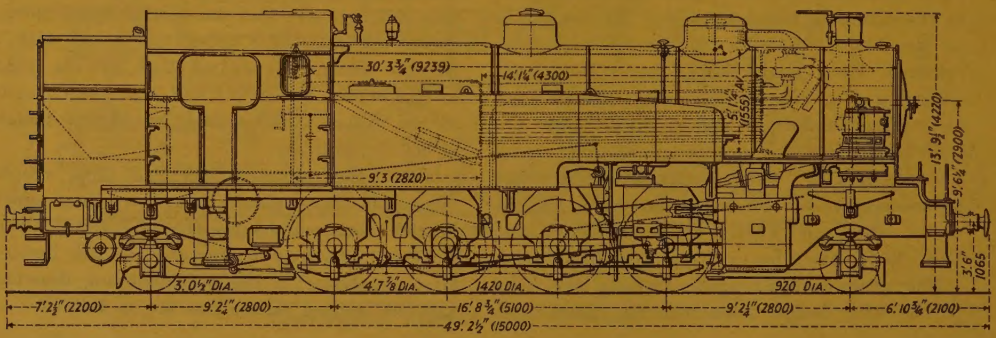
The introduction of all-steel coaches in the Paris suburban services, and the acceleration of the suburban trains to relieve the congestion on the 9-km. (5.6 miles) of the Est main line, between Paris and Noisy, necessitated the designing of a new and powerful type of tank locomotive, the first of which, No. 141.701, was built in the company's works at Epernay about four years ago. There are now 42 of these locomotives in service, and so successful was the design that the French State Railways also built 40 for their heavy Paris suburban traffic.

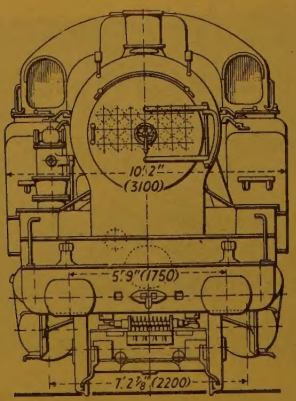
The general requirements forming the basis of the new design were that the locomotives should be capable of very rapid starting and acceleration, with trains weighing 510 metric tons (492 E. tons) ; that the average speed should exceed 60 km. (37.3 miles) per hour, with a possible maximum speed of 90 to 100 km. (55.9 to 62.1 miles) per hour ; and that the capacity of the water tanks should be 13 cu. metres (2 860 Br. gallons).

The design adopted was that of a simple-expansion three-cylinder machine using superheated steam and having the 2-8-2 wheel arrangement. The general features of the locomotive are shown in the accompanying drawing, and the leading dimensions are as follows :

Cylinders, diameter	510 mm. (20 in.).
» stroke	660 mm. (26 in.).
Wheels, coupled, diameter . . .	1 420 mm. (4 ft. 8 in.).
» bissel, diameter	920 mm. (3 ft. 0 1/4 in.).
Wheelbase, rigid	5 100 mm. (16 ft. 8 3/4 in.).
» total engine	10 700 mm. (35 ft. 1 1/4 in.).
Boiler working pressure	14 hectopièzes (203 lb. per sq. in.).
Boiler mean diameter	1 555 m. (5 ft. 1 1/4 in.).
Heating surface	
Flues and tubes	122.33 m² (1 316 sq. ft.).
Firebox	17.30 m² (186 sq. ft.).
Total	139.63 m² (1 502 sq. ft.).
Superheater	45.28 m² (487 sq. ft.).
Combined total	184.91 m² (1 989 sq. ft.).







General view (at La Villette), front and side elevations of new 2-8-2 three cylinder, simple expansion tank locomotive, Est Railway.

Grate area	2.80 m² (30.13 sq. ft.).
Adhesion weight	74.99 metric tons (73.8 Engl. tons).
Weight of engine in working order.	107.3 t. (105.6 Engl. tons).
Water capacity	13.05 m³ (2 871 Br. gallons).
Fuel capacity	4.027 m³ (142.2 cub. ft.).

The leading and trailing bissels are identical in design and arranged symmetrically with regard to the coupled wheels. Their lateral displacement is 130 mm. (5 1/8 inches) on each side of the centre line, and the locomotive can negotiate satisfactorily a curve of 90 m. (4 1/2 chains) radius.

The diameter of the coupled wheels, 1 420 mm. (4 ft. 8 in.), is small for the speeds required but facilitates rapid starting. The springing is uncompensated throughout. The three crank pins are set at 120 degrees, the outside horizontally-placed cylinders driving the third coupled axle, and the inside inclined cylinder driving the second coupled axle. Special nickel-chromium steel is used for the connecting and coupling rods. Unlike the arrangement used in the company's other three-cylinder locomotives, the valve motion of the inside cylinder is not actuated by the combination of the two outside motions. It is independent and incorporates a link operated by an eccentric mounted on the leading coupled axle. There is only one reversing gear for the three valve motions, which latter are of the Walschaerts type. This arrangement is considered preferable in view of the high speed of the locomotives and the small diameter of their driving wheels.

The piston valves, 250 mm. (9 7/8 inches) diameter, are of the light stamped plate type, similar tho those of the 41.001 locomotives, and their action provides the same features of long stroke and large openings, even at an early cut-off. No tail-rods are provided either on the pistons or the piston valves. The piston segments are arranged like those of the piston valves, and the rings are of bronze in order to reduce to a minimum the wear on the cylinder liners. Systematic tests show that this arrangement gives excellent results as regards steam tightness, support of the segments, and wear on the cylinders. A great part of the wear occurs on the bronze rings, which are easily replaceable when, after two successive rotations of 120 degrees, the wear has become practically the same on the different diameters. The cylinder lubrication is effected by a type GRHM mechanical lubricator with sight-feed and pipes terminating above each of the two piston valve heads; at the centre of the upper generatrix of the cylinders; and in the high pressure steam cylinder of the brake pump.

The boiler is of the type most extensively used on the Est system, with flat-crowned Belpaire firebox, a narrow grate between the frames, twenty-one flues of 125/133 mm. (4.921/5.236 in.) diameter, and 141 tubes of 45/50 mm. (1.771/1.968 in.) diameter. A 21-element superheater of the D. M. type is fitted. The regulator valve, in the dome, is of the balanced single-seated type; and a variable blast pipe is provided. The boiler may be operated at a pressure of 16 hectopiezes (232 lb. per sq. in.), but the working pressure is provisionally fixed at 14 hectopiezes (203 lb. per sq. in.). The locomotive is fitted with a Westinghouse brake, and the hand brake has a ratio which makes it capable of exerting a force on the brake shoes practically equal to that developed by the compressed air brake.